National Aeronautics and
Space Administration

NSTS 07700–10–MVP–09
REVISION B
NOVEMBER 19, 1993

Lyndon B. Johnson Space Center
Houston, Texas 77058

REPLACES
JSC 07700–10–MVP–09
REVISION A

SPACE SHUTTLE

SHUTTLE MASTER VERIFICATION PLAN

VOLUME IX
COMPUTER SYSTEMS AND SOFTWARE VERIFICATION PLAN

PART 2
VERIFICATION REQUIREMENTS

REVISION LOG

REV LTR	CHANGE NO	DESCRIPTION	DATE
		BASELINE ISSUE (Reference: Level II PRCBD S01751B)	10/10/75
A	11	REVISION A (Reference: Level II PRCBD S40129, dated 7/23/86) also includes PRCBD S40349 and Changes 1 thru 10.	11/24/86
B	20	REVISION B (Reference: SSP DOC–125, dated 8/11/93) also includes Space Shuttle PRCBDs S004600G, S004600J, S052730A and Changes 12 thru 19.	11/19/93

CHANGE SHEET

FOR

PROGRAM DEFINITION AND REQUIREMENTS
SHUTTLE MASTER VERIFICATION PLAN
VOLUME IX – Computer Systems and Software Verification Plan
Part 2 – Verification Requirements

CHANGE NO. 24

Program Requirements Control Board Directive No. S061461/(3-1), dated 6/19/00.(1)

July 12, 2000

Robert H. Heselmeyer
Secretary, Program Requirements
Control Board

CHANGE INSTRUCTIONS

1. Remove the following listed pages and replace with the same numbered attached pages:

Page	PRCBD No.
5-13	S061461
5-14	
5-15	S061461
5-16	
A-3 - A-5	S061461
A-6	

NOTE: A black bar in the margin indicates the information that was changed.

2. Remove the List of Effective Pages, dated May 25, 2000 and replace with List of Effective Pages, dated July 12, 2000.

3. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind the List of Effective Pages.

_____ _____

Signature of person incorporating changes Date

PROGRAM DEFINITION AND REQUIREMENTS
SHUTTLE MASTER VERIFICATION PLAN
VOLUME IX - Computer Systems and Software Verification Plan
Part 2 - Verification Requirements

*Revision B (Reference PRCBD Nos. S004600G, dated 6/23/93; S004600J, dated 10/21/93; S052730A, dated 10/21/93 and SSP DOC-125)

LIST OF EFFECTIVE PAGES

July 12, 2000

The current status of all pages in this document is as shown below:

Page No.	Change No.	PRCBD No.	Date
i	Rev. B	*	November 19, 1993
ii	23	S052558E	July 29, 1994
iii	23	S061427 S071024EB	April 28, 2000, October 28, 1997
iv	Rev. B	*	November 19, 1993
v	22	S071024GL	August 31, 1999
vi - x	Rev. B	*	November 19, 1993
1-1	Rev. B	*	November 19, 1993
1-2	23	S061427	April 28, 2000
1-3 - 1-8	Rev. B	*	November 19, 1993
1-9	23	S061427	April 28, 2000
1-10 - 1-12	Rev. B	*	November 19, 1993
2-1 - 2-2	Rev. B	*	November 19, 1993
2-3	22	S071024GL	August 31, 1999
2-4 - 2-5	Rev. B	*	November 19, 1993
2-6	23	S061427	April 28, 2000
3-1 - 3-8	Rev. B	*	November 19, 1993
4-1	Rev. B	*	November 19, 1993
4-2	22	S071024GL	August 31, 1999
4-3 - 4-22	Rev. B	*	November 19, 1993
5-1 - 5-2	Rev. B	*	November 19, 1993
5-3	23	S061427	April 28, 2000
5-4 - 5-7	Rev. B	*	November 19, 1993
5-8	22	S071024GL	August 31, 1999
5-9 - 5-12	Rev. B	*	November 19, 1993
5-13	24	S061461	June 19, 2000
5-14	Rev. B	*	November 19, 1993

LIST OF EFFECTIVE PAGES

July 12, 2000

Page No.	Change No.	PRCBD No.	Date
5-15	24	S061461	June 19, 2000
5-16	Rev. B	*	November 19, 1993
5-17 - 5-18	23	S061427	April 28, 2000
5-19 - 5-34	Rev. B	*	November 19, 1993
5-35	23	S061427	April 28, 2000
5-36	Rev. B	*	November 19, 1993
6-1 - 6-8	Rev. B	*	November 19, 1993
A-1 - A-2	Rev. B	*	November 19, 1993
A-3 - A-5	24	S061461	June 19, 2000
A-6	23	S061427	April 28, 2000
B-1 - B-5	Rev. B	*	November 19, 1993
B-6	23	S061427	April 28, 2000
B-7 - B-16	Rev. B	*	November 19, 1993

NSTS 07700–10–MVP–09
PART 2

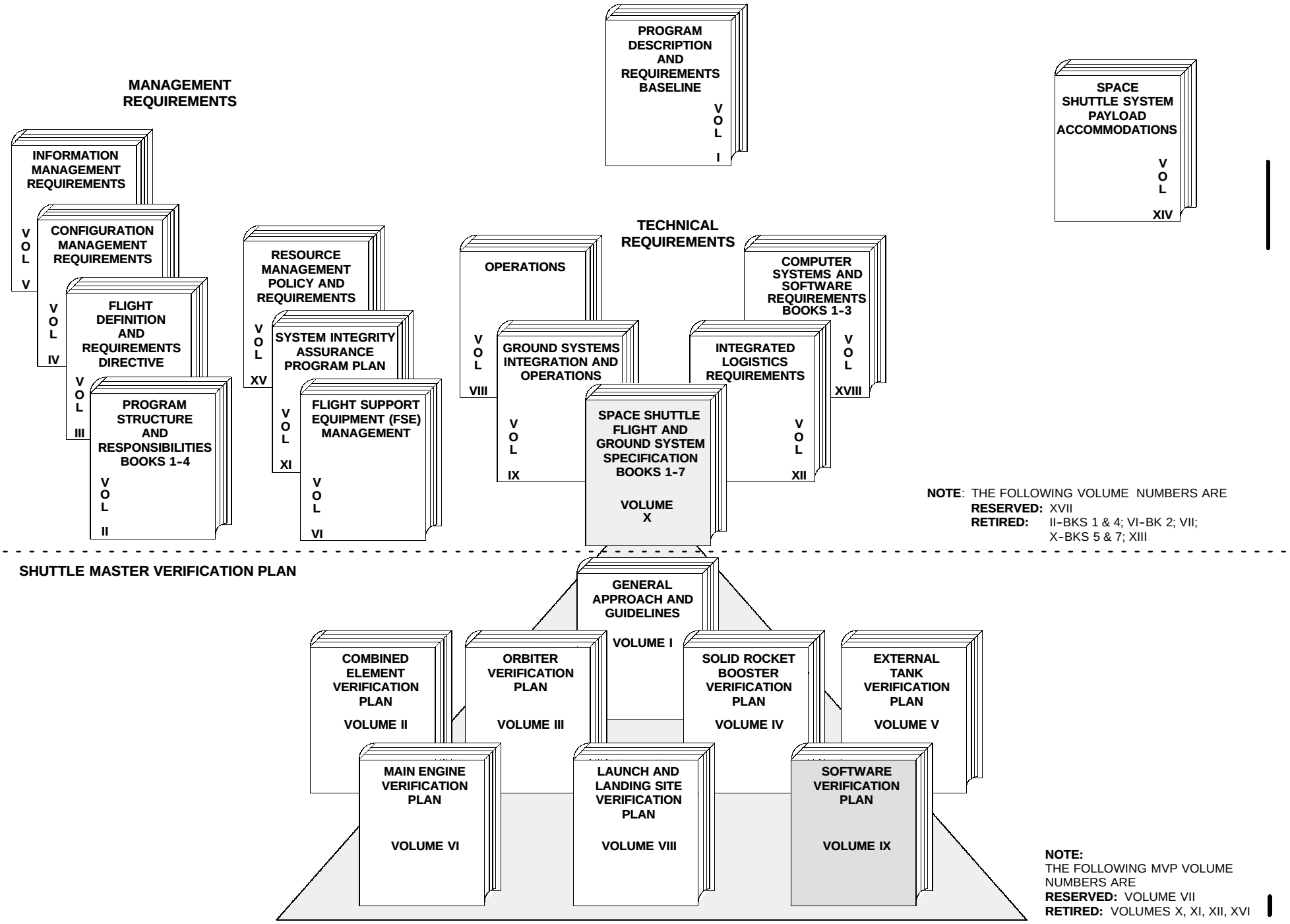
SPACE SHUTTLE

SHUTTLE MASTER
VERIFICATION PLAN

VOLUME IX
COMPUTER SYSTEMS AND SOFTWARE
VERIFICATION PLAN

PART 2
VERIFICATION REQUIREMENTS

SPACE SHUTTLE
PROGRAM DEFINITION & REQUIREMENTS – NSTS 07700



FOREWORD

Efficient management of the Space Shuttle Program (SSP) dictates that effective control of program activities be established. Requirements, directives, procedures, interface agreements, and system capabilities shall be documented, baselined, and subsequently controlled by SSP management.

Program requirements, directives, procedures, etc., controlled by the Program Requirements Control Board (PRCB), are documented in the volumes of this document, NSTS 07700. The accompanying illustration identifies the volumes that make up the Space Shuttle Program Definition and Requirements. Volume I contains overall descriptions of the NSTS 07700 documentation. Requirements to be controlled by the NASA project managers are to be identified, documented, and controlled by the project.

Volumes I, II and IX of the Space Shuttle Master Verification Plan are approved by the PRCB. Project verification plans documented as Volumes III through VI and VIII are approved and controlled by the respective NASA project offices. Project volumes are maintained as directed by the respective project office.

Volume IX of the Shuttle Master Verification Plan contains the Shuttle Program Computer Systems and Software Verification Plan. Part I of this volume identifies the guidelines and standards for verification/validation of major computer systems and software, and Part II identifies the SSP computer system integration verification/ validation requirements. The Office of Primary Responsibility for NSTS 07700–10–MVP–09 is the Avionics and Software Office.

All elements of the SSP must adhere to these baselined requirements. When it is considered by the Space Shuttle Program element/project managers to be in the best interest of the SSP to change, waive or deviate from these requirements, an SSP Change Request (CR) shall be submitted to the Program Requirements Control Board (PRCB) Secretary. The CR must include a complete description of the change, waiver or deviation and the rationale to justify its consideration. All such requests will be processed in accordance with NSTS 07700, Volume IV – Book 1, and dispositioned by the Manager, Space Shuttle Program, on a Space Shuttle PRCB Directive (PRCBD).

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Ronald D. Dittemore
Manager, Space Shuttle Program

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APPENDICES

TABLES

FIGURES

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1.0 INTRODUCTION

1.1 PURPOSE

Part II of Volume IX defines the Space Shuttle Program (SSP) verification requirements for the Space Shuttle Program integrated computer systems. The purpose of the document includes:

a. Identification of integrated computer systems software/hardware verification requirements.

b. Definition of verification philosophy.

c. Specification of the criteria which define the acceptability of the test results.

1.2 SCOPE

This plan is applicable to verification of Space Shuttle Program operational integrated computer systems. These requirements encompass all SSP interfaces that involve programmable computers or programmable non–computer devices interfacing with another flight or ground element of the Space Shuttle system (including computer or hardware interfaces). These include all Shuttle Flight Systems and flight system interfaces with other operational systems, e.g., ground checkout, ground test, ground operations, ground flight control and communications.

Section 3 discusses general integration testing philosophy.

Section 4 describes the integrated computer system verification requirements for the Shuttle Flight System. For each established requirement, the test specification and acceptance criteria are indicated. The interfaces covered in this section are:

Orbiter – External Tank

Orbiter – Solid Rocket Booster

Orbiter – Main Engine

Orbiter – Payload

Section 5 describes the integrated computer system verification requirements that must be satisfied to verify the Shuttle Flight System/Ground Processing System interface hardware/software compatibility. The interfaces covered in this section are:

Orbiter Systems/Hypergolic Maintenance and Checkout Station	(KSC)
Spacelab/Spacelab Processing Facility	(KSC)

Payloads/Inertial Upper Stage Processing Facility	(KSC)
Orbiter/ORB Processing Facility	(KSC)
External Tank/ET Processing and Storage Station	(KSC)
Space Shuttle/Shuttle Vehicle Assembly and Checkout Station	(KSC)
Space Shuttle/Launch Pad Station	(KSC)
Orbiter/VAC	(Palmdale)
Orbiter/VAC	(Edwards AFB)
Orbiter Systems/Hypergolic Servicing Facility	(VAFB)
Orbiter/SRB Maintenance and Checkout Facility	(VAFB)
External Tank/Tank Checkout Facility	(VAFB)
SRB/SRB Receiving and Storage Facility	(VAFB)
SRB/SRB Disassembly Facility	(VAFB)
Space Shuttle/SS Launch Pad	(VAFB)
Orbiter/Safing and Deservicing Facility	(VAFB)

Section 6 describes the integrated computer system requirements that must be satisfied to verify Shuttle Flight System/Flight Operations System interface hardware/software compatibility. The interfaces covered in this section are:

Orbiter/MCC

Orbiter/POCC

Orbiter/AFSCF

Orbiter/Detached Payload

MCC/LPS/Network

These include all Shuttle Flight Systems and their interfaces with other operational systems; e.g., Ground Processing Systems and Flight Operations Systems including communications (see Figure 1–1).

1.3 IMPLEMENTATION MANAGEMENT PLAN AND MATRIX

A management plan and a matrix have been developed to provide perspective of implementation of the Shuttle Master Verification Plan, NSTS 07700–10–MVP–09, Part II, Verification Requirements, in this document.

The management plan describes the organizations involved and the plan for accomplishing the total verification tasks as described in the “Space Shuttle Program Management Plan for Computer Systems Hardware/Software Integration Review (CSIR)”.

The matrix in Table 1.1 allocates the verification requirements of this volume among the major Shuttle Integration Test Facilities: SAIL, KSC, and VAFB. Other supporting interface testing is also identified. The requirements are identified in Table 1.1 by reference to table and item numbers or by section number. The details of the requirements are contained in subsequent sections of this document.

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TABLE 1.1

INTEGRATED COMPUTER SYSTEM VERIFICATION MATRIX

	REQUIREMENT	VAFB	KSC	SAIL	SSC	PMDL
Table 4.2: ORB/ET						
1	OFI Data			V	S	
2	DFI Data		V		P	
3	Interface Test: (A) OI			V	S	E
	(B) OFI		V		S	E
4	Status & Fault Isolation			V	S	
5	In–flight Monitoring			V	S	
6	Separation			V		
7	BFS OFI Data			V		
Table 4.3: ORB/SRB						
1	OFI Data			V		E
2	DFI Data		V			E
3	Interface Test			V		E
4	Mode Control (+ Commands)			V		
5	Status + Fault Isolation			V		
6	Launch Control			V		
7	In–flight Processing			V		
8	Separation			V		
9	BFS OFI Data			V		
Table 4.4: ORB/SSME						
1	Memory Load			V	S	
2	Data Processing			V	S	E
3	Commands			V	S	E
4	Status + Fault Isolation			V	S	
5	Interface Test			V	S	
6	Flight Readiness Test			V	S	
7	Launch Control			V	S	
8	In–flight Processing			V	S	
9	In–flight Processing – OFF Nominal			P	S	

TABLE 1.1

INTEGRATED COMPUTER SYSTEM VERIFICATION MATRIX – Continued

	REQUIREMENT	VAFB	KSC	SAIL	SSC	PMDL
Table 4.5: ORB/PLD						
1	Interface Verification			E		E
2	Data Monitor			E		E
3	Payload Checkout			E		
4	In–flight Data Monitor			E		
5	In–flight Payload Initialization			E		
6	In–flight Control			E		
Table 5.1: LPS/GPC						
1	TCS Sequences			V		
2	TCS 1 for 1 Operations			V		
3	SACS Operations			V		
4	MMU Operations			V		
5	SSMEC Memory Load			V		
6	Countdown Commands			V		
7	PLD Data Transfer			E		
8	Alternate LDB			V		
9	LDB Switchover			V		
Table 5.2: LPS/CD MDM						
1	Commands			V		
2	Data (UP)			V		
4	Data (DOWN)			V		
Table 5.3: Umbilicals						
1	SSME Data			V		
2	PCMMU Data			V		E
3	Recorder Data + Control		V			E
4	Network Signal Processor Data (2 WAY)			V		
+ 5	DFI – PCMMU Data		V			E
+ 6	DFI Recorder Data & Control		V			E

TABLE 1.1

INTEGRATED COMPUTER SYSTEM VERIFICATION MATRIX – Continued

	REQUIREMENT	VAFB	KSC	SAIL	SSC	PMDL
Table 5.3: Umbilicals (Concluded)						
+ 7	Wideband Recorder Data & Control		V			E
+ 8	FDM Data		V			E
9	Payload Data		V			
10	Payload Data Via FM					
11	Payload Recorder Control					
Table 5.4: SRB/LPS						
1	PCM Multiplexer Data (TP)		V1,2		S	
2	FM Multiplexer Data (TP)		V		S	
3	Flight Recorder Data & Control (TP)		V		S	
Table 5.5: ET/LPS						
1	PCM Data		V			
2	FM Data		V			
3	OI Data		V			
4	System Control					
5	Systems Testing					
6	Fault Isolation					
Table 5.2.1: Orbiter Integrated Checkout						
0	Orbiter Compatibility Test			P	P	V
Table 5.2.2: Orbiter Systems Verification						
1	System Testing		V	P	P	
2	Fault Isolation		V		P	
3	Orbiter/SSME Testing		V	P		
4	Orbiter/Payload Testing		V	E		E

TABLE 1.1

INTEGRATED COMPUTER SYSTEM VERIFICATION MATRIX – Continued

	REQUIREMENT	VAFB	KSC	SAIL	SSC	PMDL
Table 5.2.3: Orbiter Integrated Test						
0	Orbiter Intergrated Test		V	P	P	
Table 5.2.4: Shuttle Integrated Checkout						
1	Systems Control		V	P	P	
2	Orbiter/ET Testing		V	P		
3	Orbiter/SRB Testing		V	P		
4	Shuttle Integrated Test		V	P	P	
Table 5.2.5: Payload Integrated Test						
1	Spacelab		V	E		
2	Attached/Detached Payloads		V	E		
3	Inertial Upper Stage		V	E		
Table 5.2.6: Prelaunch Testing						
1	Shuttle/Launch Pad Test		V			
2	Plugs In Test					
3	Plugs Out Test		V			
4	MCC/Orbiter Interface Test		V			
5	Wet Countdown Test		V	P		
6	Flight Readiness Firing		V	P		
7	Dry Countdown Test		V	P		
8	Launch Readiness Verification		V	P		
9	Safety Servicing		V	P		
10	Countdown		V	P		
Table 6.1: Orbiter/MCC VIA STDN						
1	Uplink Commands		V	P*		
2	Telemetry Downlink–PM RF		V	P*		
3	Telemetry Downlink–FM RF		V	P*		
+ 4	DFI Telemetry Downlink–FM RF		V			P

TABLE 1.1

INTEGRATED COMPUTER SYSTEM VERIFICATION MATRIX – Concluded

	REQUIREMENT	VAFB	KSC	SAIL	SSC	PMDL
Table 6.2: Orbiter/MCC VIA TDRSS						
1	Uplink Commands – 'S' Band		V	P*		
2	Telemetry Downlink – 'S' Band		V	P*		
3	Uplink Commands – Ku Band		V	P*		
4	Telemetry Downlink – Ku Band		V	P*		
Table 6.3: Orbiter/Detached Payload						
1	ORB/PLD Uplink – 'S' Band		V	E		
2	ORB/PLD Downlink – 'S' Band		V	E		

NOTES:

V – Verification Requirement – Mandatory for verification of computer systems.

P – Verification Requirements, Partial – Verification is limited by hardware or software fidelity.

S – Supplemental Testing – Monitoring of existing testing for early supplemental information.

E – Element Testing – Monitoring of existing element testing for early supplemental data.

1 – MSFC Responsibility at SRB Processing Facility.

2 – KSC Responsibility at MLP.

* – SAIL/ESTL – Limited MCC interface.

+ – For MADS Configured Vehicles, refer to Appendix B for requirements.

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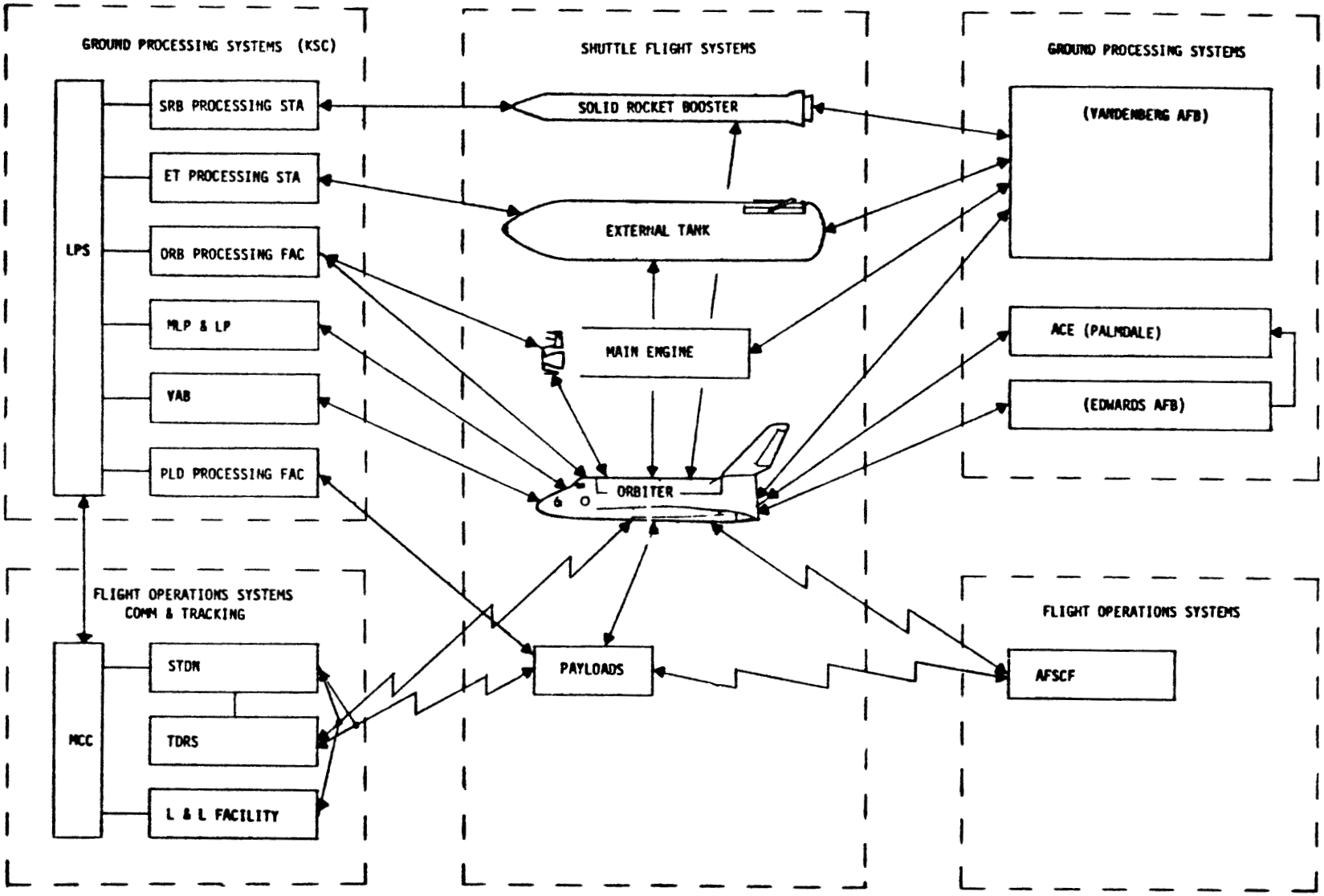
FIGURE 1–1

SPACE SHUTTLE INTEGRATED COMPUTER SYSTEM HARDWARE/SOFTWARE INTERFACES

NASA-S-76-4433



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2.0 APPLICABLE DOCUMENTS

The following documents of the date and issue shown form a part of this document to the extent specified herein. "(Current Issue)" is shown in place of a specific date and issue when the document is under Space Shuttle PRCB control. The current status of documents shown with "(Current Issue)" may be determined from NSTS 08102, Program Document Description and Status Report.

NSTS 07700, Volume I (Current Issue)	Program Description and Requirements Baseline
	Ref. Foreword
NSTS 07700, Volume IV (Current Issue)	Configuration Management Requirements
	Ref. Foreword
NSTS 07700, Volume X (Current Issue)	Space Shuttle Flight and Ground System Specification
	Ref. Para. 4.0, 4.1, 4.4
NSTS 07700, Volume X, Book 1 (Current Issue)	Space Shuttle Flight and Ground System Specification, Requirements
	Ref. Table 4.1, 4.2, 4.3, 4.5, 5.1, 6.3
NSTS 07700, Volume XIV (Current Issue)	Space Shuttle Systems Payload Accommodations
	Ref. Para. 4.4, Table 4.1

NSTS 07700, Volume XVIII (Current Issue)	Computer Systems and Software Requirements, Book 1, Allocation of Computational Functions Ref. Para. 4.0, 4.1, 4.2, 4.3, 4.4, 5.0, 5.1, Table 4.2, 4.3, 4.4, 4.5, 5.1, 5.2, 5.3, 5.4, 5.5, 6.1, 6.2, 6.3, B5.3, B6.1
NSTS 07700–10–MVP–01 (Current Issue)	Shuttle Master Verification Plan – General Approach and Guidelines, Volume I Ref. Foreword, Table 5.3, B5.3
NSTS 07700–10–MVP–02 (Current Issue)	Shuttle Master Verification Plan – Combined Element Verification Plan, Volume II Ref. Foreword, Para. 3.3
JSC 07700–10–MVP–03	Orbiter Verification Plan, MJ072–0004–3, Volume III Ref. Foreword, Para. 3.1
JSC 07700–10–MVP–04	Solid Rocket Booster Verification Plan, SE–019–019–2H and TRW–15723, Volume IV Ref. Foreword, Para. 3.1
JSC 07700–10–MVP–05	External Tank Verification Plan, MMC–ET–TM01–1, Volume V Ref. Foreword, Para. 3.1
JSC 07700–10–MVP–06	Main Engine Verification Plan, DVS–SSME–NNN, Volume VI Ref. Foreword, Para. 3.1

JSC 07700–10–MVP–08	Launch and Landing Site Verification Plan, (KSC–K–STSM–09 – Volume IV – Supplement), Volume VIII Ref. Foreword, Para. 3.1
NSTS 08171	Operations and Maintenance Requirements and Specifications Document (OMRSD) Ref. Para. 4.4
NSTS 14046 August 1980	Payload Interface Verification Requirements Ref. Para. 4.4
NSTS 21000–A04	Command and Data Ref. Para. 5.2.5.2, Table 5.1
NSTS 21000–A08	Launch Site Support Plan Ref. Para. 5.3.1.3, 5.3.1.4
NSTS 21000–IDD–MDK	Interface Definition Document for Middeck Accommodations Ref. Para. 4.4.2
NSTS 21000–IDD–SML	Interface Definition Document for Small Payload Accommodations Ref. Para. 4.4.3

NSTS 21000–IDD–STD	Interface Definition Document for Standard Accommodations Ref. Para. 4.4.4
ICD D–E0001	Shuttle Orbiter/Inertial Upper Stage Cargo Element Interfaces Ref. Para. 4.4.5, 5.2.5.3, 5.3.1.4
ICD 13M15000	Orbiter Vehicle/Main Engine Ref. Para. 3.2, 4.3, 5.3.1.5, Table 4.1, 4.4
ICD 2–0A001	Space Shuttle System/VAB Ref. Para. 3.3
ICD 2–0A002	Shuttle System/Launch PAD and MLP Ref. Para. 3.3, 5.2.6.1
ICD 2–0A003	Flight Vehicle/LPS Computational Systems Interfaces Ref. Para. 3.3, Table 5.3, 5.4, 5.5, B5.3, B6.1
ICD 2–0A004	Space Shuttle Systems/KSC RF Communications and Tracking Interface Control Document Ref. Table 6.1, 6.2
ICD 2–0D003	Shuttle Communication and Tracking/USAF Interface Control Document Ref. Para. 3.3, 6.2.1, 6.2.2

ICD 2–0D004	JSC/GSFC Space Shuttle Communication and Tracking Ref. Para. 3.3, 5.2.6.4
ICD 2–1A001	Orbiter Landing Station Ref. Para. 5.3.3
ICD 2–1A002	Orbiter Processing Facility Ref. Para. 3.2, 5.3.1.5
ICD 2–1A003	Orbiter/Hypergolic Station Ref. Para. 3.2, 5.3.1.1
ICD 2–1D003	Orbiter Secondary Landing Station Interfaces Ref. Para. 5.3.3
ICD 2–12001	Orbiter Vehicle/External Tank Ref. Para. 3.2, 4.1, 5.3.1.5, Table 4.1, 4.2
ICD 2–14001	Orbiter Vehicle/Solid Rocket Booster Ref. Para. 3.2, 4.2, 5.3.1.5, Table 4.1, 4.3
ICD 2–17001	Orbiter/Carrier Aircraft Ref. Para. 4.5, Table 4.1
ICD 2–2A001	External Tank (ET)/Receiving, Storage and Checkout Station Ref. Para. 3.2, 5.3.1.6

ICD 3-0607-01 (Use of Latest Revision is Authorized)	VAC/ORB/GSE-Palmdale Bldg 294, Functional
	Ref. Para. 5.3.2, Apx. B, 5.3.2
JSC 18206	Shuttle Data Integration Plan (DIP)
	Ref. Table 4.2, 4.3, 5.3; Apx B, Table B5.3
CPDS SS-P-0002-150I February 1988	OFT LDB S/W Interface Requirements
	Ref. Para. 5.1.1.1, 5.1.1.2, Table 4.3, 5.1, 5.2
K-STSM-11.0	Launch Site Support Plan – Horizontal Payload
	Ref. Para. 5.3.1.3
K-PSM-11.01	Launch Site Support Plan – Deployable Payload
	Ref. Para. 5.3.1.4

3.0 COMPUTER SYSTEMS INTEGRATION VERIFICATION PHILOSOPHY

Hardware/Software Computer Systems Integration Verification is performed to ensure that the design and development of the multiple software/hardware systems are compatible and are adequate to meet Space Shuttle performance requirements. The criteria for verification is completion of sufficient testing or analysis to show that appropriate hardware/software design, functional, and user requirements are met. Potential interface problems can be isolated in a timely manner if the verification process progresses in an orderly fashion from individual element tests and analysis through complete multi–element systems verification. Table 3.1 summarizes the objectives and characteristics of three categories of verification which are discussed below.

3.1 ELEMENT INTERFACE VERIFICATION

Master Verification Plans (MVPs) for Shuttle elements describe the formal verification that must be satisfied to verify the element for each major program milestone. Each plan describes the test and analysis program, identifies the verification requirements and the method of verification for each element (reference Paragraph 2.0 Applicable Documents: MVP–03, MVP–04, MVP–05, MVP–06 and MVP–08). Element interface verification will demonstrate that each element of the Shuttle System can send and receive the electrical and electronic signals as specified by the ICD. Responses and interface characteristics of the element(s) mating with the element under test will be provided by test hardware or simulated. Figure 3–1 is a block diagram of the element interface verification test configuration. Element verification will ensure the readiness and operational integrity of each element, its ability to operate with the allowable range of interfacing input data, and the extent of the variations in its output data. The tests will be done normally as a part of the overall element/project element verification testing. Although not an integral part of integration testing, element verification will be monitored to ensure that a suitable data base is established for later higher level tests.

3.2 ELEMENT/ELEMENT INTERFACE VERIFICATION

This activity will verify the hardware/software functional capability of the element–to–element interfaces when two or more Shuttle elements are mated. It will ensure that the data sent by one element are properly received and interpreted by the other element. Element–to–element tests will be end–to–end stimulus/response tests where a set of stimuli issued by one element across the operational interface is verified by the proper set of responses in the other element. Verification of redundant paths will be included where applicable. Data variation and timing will be investigated. Figure 3–2 is a block diagram of the element/element interface testing configuration. Interface Control Documents (ICDs) define, identify and control the design of the physical and

functional interfaces between elements and ground systems and facilities (reference Paragraph 2.0 Applicable Documents: ICDs 2–12001, 2–14001, 13M15000, 2–1A002, 2–1A003 and 2–2A001).

3.3 INTEGRATED SYSTEMS VERIFICATION

Shuttle System Master Verification Plan, Volume II, Combined Element Verification Plan, describes the formal verification that must be satisfied for each major milestone. The plan describes the test and analysis program, identifies the combined elements and system level verification required and the method of verification. Operational readiness of the total Shuttle System will be verified by these tests. Shuttle computer system components will be demonstrated to perform according to Shuttle System design, functional and operational requirements. Integrated systems tests provide closed loop, end–to–end verification of the interfaces. Integrated systems tests will also provide realtime interactive verification of the Shuttle System operation including checkout, ground turnaround, launch and mission control. ICDs define, identify and control the design of the physical and functional interfaces (reference Paragraph 2.0 Applicable Documents: ICDs 2–0A001, 2–0A002, 2–0A003, 2–0D003 and 2–0D004).

The configuration for integrated systems test is similar to that shown in Figure 3–3.

TABLE 3.1

CATEGORIES OF VERIFICATION FOR SHUTTLE COMPUTER SYSTEMS

VERIFICATION CATEGORY	OBJECTIVES TEST/ANALYSIS	TYPES OF TEST/ANALYSIS PERFORMED	COMMENTS

1. ELEMENT INTERFACE VERIFICATION	• Verify compliance with ICD
	  • Signal levels
	  • Message formats
	• Verify input acceptance
	• Verify output generation
		• Output signal measurement
		• Stimulus/Response at interface
		• Analysis
			• Use hardware and/or software element simulation

2. ELEMENT/ELEMENT INTERFACE VERIFICATION	• Verify functional operation of interface signals • Verify commands from one element are executed in another as required • Verify instrumentation interfaces	• Stimulus/Response from one element to another • Functional interface analysis	• Performed only with actual Shuttle inter–facing hardware
3. INTEGRATED SYSTEM VERIFICATION	• Verification of end–to–end (stimulus to response) functions • Verify operational readiness of total Shuttle System • Verify functional and opera–tional compatibility of interfacing elements	• Integrated systems tests • Simulated mission phases • Simulated orbital operations • Typical ground operations	• Actual mechanical motion, pneumatic and fluid flow • Thrusting indications simulated except for MPT and FRF

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FIGURE 3–1

ELEMENT INTERFACE TEST CONFIGURATION

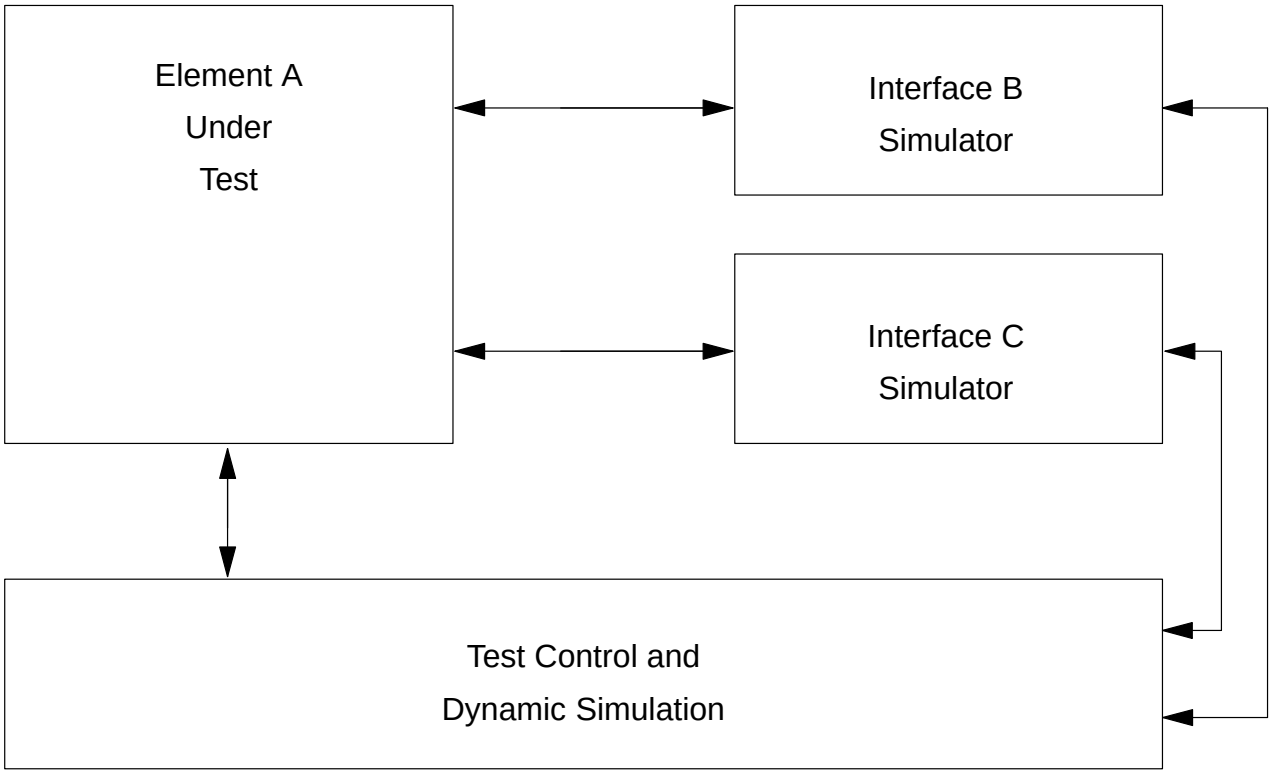


FIGURE 3–2

ELEMENT/ELEMENT INTERFACE TEST CONFIGURATION

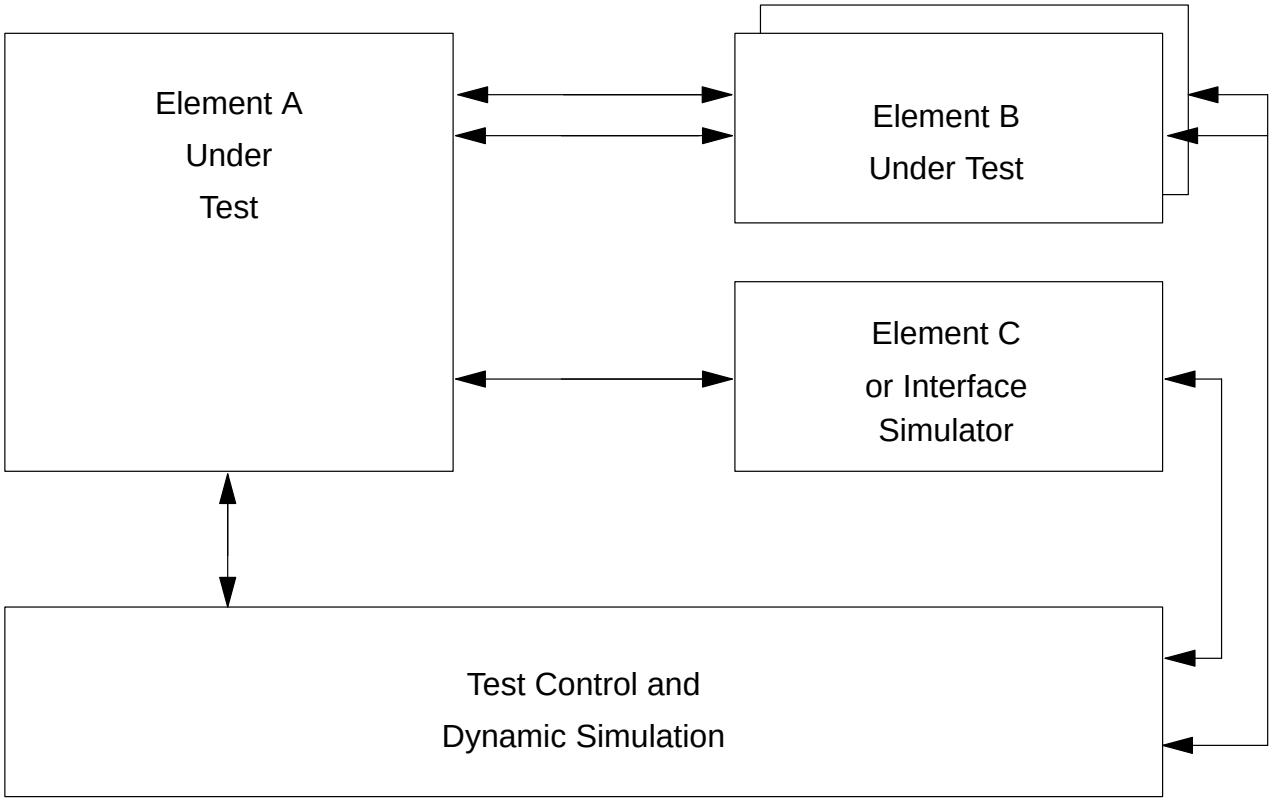
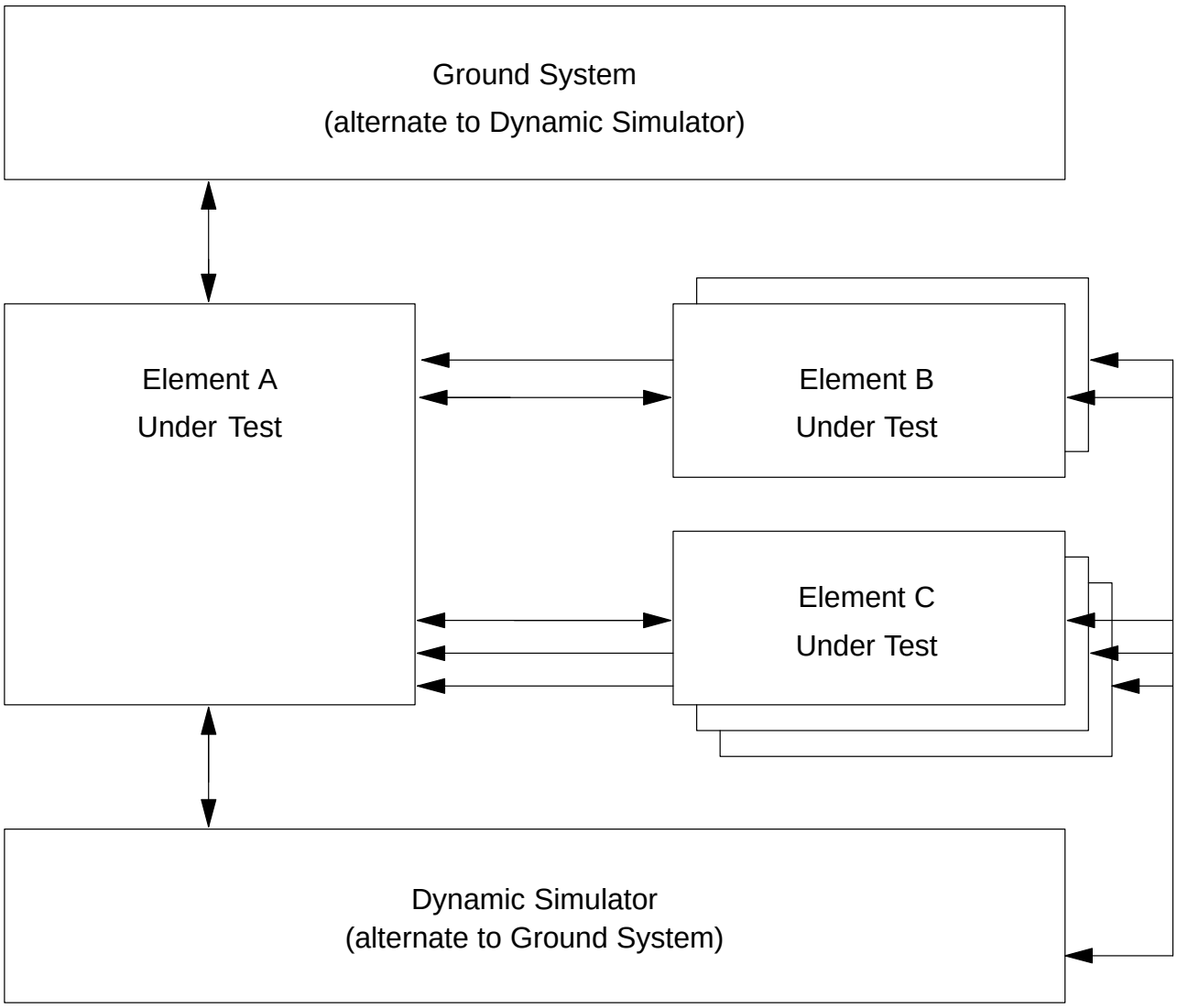


FIGURE 3–3

INTEGRATED SYSTEM TEST CONFIGURATION



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4.0 FLIGHT SYSTEMS REQUIREMENTS

This section defines the flight system Space Shuttle verification requirements that must be satisfied to meet the software/hardware performance requirements of the Space Shuttle Flight and Ground Systems Specification (NSTS 07700, Volume X) and Computer Systems and Software Requirements (NSTS 07700, Volume XVIII, Bk 1). Table 4.1 provides a cross reference between the verification requirements sections, specific paragraphs of Volume X, and the appropriate Interface Control Document (ICD). The ICDs contain detailed functional interface requirements. The allocation of computational functions in Volume XVIII form the basis for the software interface verification requirements.

The remainder of this section is divided into five sections which represent the major Orbiter element interfaces:

a. Orbiter/External Tank (ORB/ET)

b. Orbiter/Solid Rocket Booster (ORB/SRB)

c. Orbiter/Main Engine (ORB/SSME)

d. Orbiter/Payload (ORB/PLD)

4.1 ORBITER/EXTERNAL TANK

The verification requirements for the Orbiter/External Tank (ORB/ET) are contained in Table 4.2. The requirements are based on NSTS 07700, Volume X and Volume XVIII, Bk 1. Additional interface definition and data are contained in ICD 2–12001. Table 4.2 also describes related requirement source, test specification and acceptance criteria for each requirement. The interface is shown in Figure 4–1.

4.2 ORBITER/SOLID ROCKET BOOSTER

Verification requirements for the Orbiter/Solid Rocket Booster (ORB/SRB) are contained in Table 4.3. The element interface data are described by ICD 2–14001. Integrated system verification requirements are based on NSTS 07700, Volume XVIII, Bk 1. The tables in this section describe related requirements source, test specifications and acceptance criteria for each requirement. Figure 4–2 is a simplified block diagram of the interface.

4.3 ORBITER/MAIN ENGINE

Verification requirements for the Orbiter/Main Engine (ORB/SSME) are contained in Table 4.4. The interface data are based on ICD 13M15000. Integrated system

verification requirements are based on NSTS 07700, Volume XVIII, Bk 1. Figure 4–3 is a simplified block diagram of the interface.

4.4 ORBITER/PAYLOADS

General verification requirements for the NASA standard Orbiter/Payload interface are contained in Table 4.5. The requirements are based on NSTS 07700, Volume X and Volume XVIII. Additional interface definition is contained in NSTS 07700, Volume XIV. The Orbiter portion of the interface is shown in Figure 4–4 for NASA payloads and Figure 4–5 for Department of Defense (DOD) payloads.

Since many different payloads are envisaged during the Shuttle program, specific payload unique requirements are given in the following subsections.

Payload unique interface requirements are contained in specific Interface Control Documents (ICDs) for each payload. Payload verification requirements are contained in NSTS 14046. Payload verification is contained in NSTS 08171, Operations and Maintenance Requirements and Specifications Document (OMRSD). The standard ICDs for different payload types and for Spacelab and the IUS are given in the following subsections.

4.4.1 (Deleted)

4.4.2 Orbiter/Middeck Payloads

Orbiter/middeck payloads requirements unique to middeck payload interfaces are specified in NSTS 21000–IDD–MDK. An ICD will be prepared for each payload and will contain unique interface requirements, if any.

4.4.3 Orbiter/Small Payloads

Orbiter/small payloads requirements unique to small payload interfaces are specified in NSTS 21000–IDD–SML. An ICD will be prepared for each payload and will contain unique interface requirements, if any.

4.4.4 Orbiter/Standard Payloads

Orbiter/standard payloads requirements unique to deployable or attached payload interfaces are specified in NSTS 21000–IDD–STD. An ICD will be prepared for each payload and will contain unique interface requirements, if any.

4.4.5 Orbiter/Inertial Upper Stage

Orbiter/inertial upper stage requirements unique to the Orbiter/IUS interfaces are specified in ICD D–E0001 (basic) and ICD D–E0001 (payload specific).

4.5 ORBITER/CARRIER AIRCRAFT

Requirements unique to the Orbiter/carrier aircraft interfaces are defined in ICD 2–17001. The only avionics interface is the electrical power from the carrier aircraft required for Orbiter LRU heaters. There are no computer systems and software requirements.

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TABLE 4.1

FLIGHT SYSTEMS REQUIREMENTS CROSS REFERENCE

		REFERENCE SECTION	
		NSTS 07700	MVP
INTERFACE	DOCUMENT NO.	VOLUME X, BK 1	VOLUME IX
ORB/ET	ICD2–12001	3.3.1.3.1	4.1
ORB/SRB	ICD2–14001	3.3.1.3.2	4.2
ORB/SSME	ICD 13M15000	3.3.1.3.4	4.3
ORB/PLD	NSTS 07700, VOLUME XIV	3.3.1.3.3	4.4
ORB/CA	ICD 2–17001	3.3.1.3.5	4.5

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TABLE 4.2

ORBITER/EXTERNAL TANK VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–12001)	ACCEPTANCE CRITERIA (ICD 2–12001)
1. Verify the capability to process ET OFI data.	Vol. XVIII, Bk 1, Para. 3.2.2, 3.3.3, 3.4.2	Verify that the ORB can process the data for onboard display and downlink by simulating ET OFI data specified in Table 3.4.6–1.	Demonstrate ORB/Payload interface status data.
2. Verify the coilability to process ET DFI data.	Vol XVIII, Bk 1, Para. 3.2.2, 3.3.3, 3.3.10, 3.4.2	Verify that the ORB can process the data for downlink by simulating ET DFI data specified in the MML and in Table 3.4.6–4 for ground operation.	Data attributes are provided in reports of the DIP (JSC 18206).
3. Verify the capability to test and verify the command data interface.	Vol XVIII, Bk 1, Para. 3.2.5	Verify that the ORB can determine and provide interface status by executing programs to generate stimuli commands to the ET. The commands are defined in Table 3.4.5–1.	Demonstrate status of system responses to each command.
4. Verify the capability to perform checkout tests to determine operational status and fault isolation.	Vol. XVIII, Bk 1, Para. 3.3.9, 3.3.11, 3.3.15	Verify that the ORB can detect and isolate ET systems faults by performing test programs and processing ET data.	ET status data is specified in Para. 3.4.5 and Tables 3.4.5, 3.4.6 and 3.4.8 of the ICD.
5. Verify Orbiter (including Backup Flight System) monitoring of ET data while in flight.	Vol. XVIII, Bk 1, Para. 3.4.6	Verify that the ORB can process programs to monitor the ET during flight by simulating the flight environment.	The monitored data is specified in Tables 3.4.5, 3.4.6 and 3.4.8 of the ICD and in the DIP (JSC 18206).

TABLE 4.2

ORBITER/EXTERNAL TANK VERIFICATION REQUIREMENTS – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–12001)	ACCEPTANCE CRITERIA (ICD 2–12001)
6. Verify Orbiter (including Backup Flight System) control of ET Separation.	Vol. XVIII, Bk 1, Para. 3.4.6	Demonstrate Orbiter/ET separation performance by simulating ascent conditions around SSME cutoff.	ET/ORB separation performance demonstrated shall be within the limits given in NSTS 07700, Volume X, Bk 1, Para. 3.2.1.1.9.2.
7. Verify the capability of the Backup Flight System to process ET OFI data which is accessible to the Backup Flight System.	Vol. XVIII, Bk 1, Para. 3.4.2	Verify that the ORB Backup Flight System can process the data for onboard display by simulating ET OFI data which is accessible to the Backup Flight System. A subset of the parameters listed in Table 3.5–1 are processed by the BFS. The subset is contained in the BFS Program Requirements Documents listed in Section 2.0.	Data attributes are provided in reports of the DIP (JSC 18206).

TABLE 4.3

ORBITER/SRB VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION* (ICD 2–14001)	ACCEPTANCE CRITERIA* (ICD 2–14001)
1. Verify the capability to process SRB and ET OI data.	Vol. XVIII, Bk 1, Para. 3.2.2, 3.3.3, 3.3.10, 3.4.2	Verify that the ORB can process the data for onboard display and downlink by simulating SRB and ET OI data as listed in Tables 3.5–1 and 3.7–1 thru 3.7–5.	Data accuracy is given in Section 3.5.2.2 and data attributes are provided in reports of the DIP (JSC 18206).
2. Verify the capability to process SRB DFI data.	Vol. XVIII, Bk 1, Para. 3.2.2, 3.3.3, 3.3.10, 3.4.2	Verify that the ORB can process the data for recording or downlink by simulating SRB DFI data as listed in Tables 3.7–1 thru 3.7–5 and the MML.	Data attributes are provided in reports of the DIP (JSC 18206).
3. Verify the capability to test and verify the ORB/ SRB command and data interface.	Vol. XVIII, Bk 1, Para. 3.2.6	The ORB shall excute programs to generate SRB stimuli commands and monitor and process data. The commands are defined in Tables 3.5–1 and 3.7–1 thru 3.7–5.	Demonstrate status of system responses to each command.
4. Verify the capability to control SRB and ET systems configurations and modes.	Vol. XVIII, Bk 1, Para. 3.3.7	Verify that the ORB does provide control of SRB and ET systems. The commands are defined in Tables 3.5–1 and 3.7–1 thru 3.7–5.	System status and data shall domonstrate the resultant configurations and modes.

TABLE 4.3

ORBITER/SRB VERIFICATION REQUIREMENTS – Continued

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION* (ICD 2–14001)	ACCEPTANCE CRITERIA* (ICD 2–14001)
5. Verify the capability to perform checkout tests to determine operational status and fault isolation.	Vol. XVIII, Bk 1, Para. 3.3.9, 3.3.11, 3.3.15	Verify that the ORB can process SRB systems test programs including tests of redundant paths and can detect and isolate SRB systems faults.	SRB systems fault status and data are contained in Para. 3.5 (Commands and Control) and Tables 3.5, 3.7 and 3.8 of the ICD.
6. Verify the capability to perform terminal countdown and launch command and control.	Vol. XVIII, Bk 1, Para. 3.3.19	Verify that the ORB does generate and issue safe and arm, actuator positioning and SRB start commands.	Demonstrate simulated SRB start as commanded by the ORB.
7. Verify ORB (including Backup Flight System) control of SRB and monitoring of SRB data while in flight.	Vol. XVIII, Bk 1, Para. 3.4.7	Verify ORB processing of programs to monitor and control the SRBs in a simulated flight environment.	The Orbiter shall control and monitor the SRB as required in CPDS SS–P–0002–1501, OFT functional level requirements, GN&C Para. 3.1 (principal functions 4.62, 4.114, 4.115 and 4.120).

TABLE 4.3

ORBITER/SRB VERIFICATION REQUIREMENTS – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION* (ICD 2–14001)	ACCEPTANCE CRITERIA* (ICD 2–14001)
8. Verify ORB (including Backup Flight System) control of SRB separation.	Vol. XVIII, Bk 1, Para. 3.4.7; Vol. X, Bk 1, Para. 3.2.1.1.9.1	Verify that the ORB can initiate SRB recovery sequence and control the SRB separation sequence.	Demonstrate Orbiter command and control as defined in Para. 3.5.3, 3.5.4 and NSTS 07700 Volume X, Bk 1, Para. 3.2.1.1.9.1.
9. Verify the capability (including Backup Flight System) to perform SSME monitoring, command, control and gimbaling under off nominal conditions.		Demonstrate SSME response to abort command sequences or fail operational and fail safe operation for simulated off nominal ascent flight including aborts or interface malfunctions.	Demonstrate the correct flight conditions under simulated environment.

TABLE 4.4

ORBITER/MAIN ENGINE VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION ICD–13M15000	ACCEPTANCE CRITERIA ICD–13M15000
1. Verify the capability to load, initialize and verify the SSMEC.	Vol. XVIII, Bk 1, Para. 3.1.2, 3.3.2	Verify that the ORB can operate on commands to load the SSMEC as specified in Section 9.4.1 and that the SSMEC can accept valid load data and can readout memory.	Demonstrate that the readout data matches the input data per Section 9.4.1.2, and that other checks specified in Section 9.4.1.1.1 are satisfied.
2. Verify the capability to process SSME data.	Vol. XVIII, Bk 1, Para. 3.1.3, 3.3.3, 3.3.10	Demonstrate ORB display and downlink of the data by simulation of SSME data as listed in Table 9.2.2–1 and 9.3.1–1.	Data shall demonstrate the accuracy and intervals of Table 9.3.1–1 and Section 8.5.
3. Verify the capability to command the SSMEC processing and operational modes.	Vol. XVIII, Bk 1, Para. 3.1.5, 3.3.6, 3.3.7	Demonstrate that the ORB can command the SSMEC processing and modes through the command structure listed in Table 8.3–1.	Demonstrate commands and SSME response as defined by Tables 8.3.5–1 and 8.3–1.
4. Verify the capability to conduct SSME testing to determine status and fault isolation.	Vol. XVIII, Bk 1, Para. 3.3.10, 3.1.9, 3.3.11	Demonstrate that the ORB can generate commands, the SSMEC can execute test programs, and the SSMEC shall provide appropriate data as specified in Sections 9.4.2 and 9.4.4.	Demonstrate SSME status as defined by Table 9.2.2–1 and data sufficient to allow fault isolation. (see Table 9.3.1–1.)

TABLE 4.4

ORBITER/MAIN ENGINE VERIFICATION REQUIREMENTS – Continued

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION ICD–13M15000	ACCEPTANCE CRITERIA ICD–13M15000
5. Verify the capability to test and verify the ORB/ SSME command and data interface.	Vol. XVIII, Bk 1, Para. 3.1.11	Demonstrate that the ORB can generate stimuli commands to the SSMEC and the SSMEC can provide data required to determine interface status.	Demonstrate interface status.
6. Verify the capability to perform flight readiness tests of the SSME.	Vol. XVIII, Bk 1, Para. 3.3.15	Demonstrate that the ORB can perform flight readiness test programs including commanding the SSME and that the SSME can respond to commands, perform flight readiness programs, and provide required data as specified in Section 9.4.3.	Demonstrate flight readiness status.
7. Verify the capability to perform countdown and launch command control of the SSME.	Vol. XVIII, Bk 1, Para. 3.3.19	Demonstrate that the ORB can generate and issue the commands for safe and arm, motor positioning and SSME start and that the SSME can respond to commands and execute the start sequence.	Demonstrate SSME countdown and start sequence.
8. Verify the capability (including Backup Flight System) to perform SSME monitoring, command, control and gimballing.	Vol. XVIII, Bk 1, Para. 3.4.5	Demonstrate SSME data monitoring and control of the SSME in a simulated ascent flight environment.	Demonstrate the correct flight conditions under simulated environment.

TABLE 4.4

ORBITER/MAIN ENGINE VERIFICATION REQUIREMENTS – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION ICD–13M15000	ACCEPTANCE CRITERIA ICD–13M15000
9. Verify the capability (including Backup Flight System) to perform SSME monitoring, command, control and gimballing under off nominal conditions.		Demonstrate SSME response to abort command sequences or fail operational and fail safe operation for simulated off nominal ascent flight including aborts or interface malfunctions.	Demonstrate the correct flight conditions under simulated environment.

TABLE 4.5

ORBITER/PAYLOAD VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION	ACCEPTANCE CRITERIA
1. Verify the capability to test and verify the ORB/ Payload command and data interface.	Vol. XVIII, Bk 1, Para. 3.1.13, 3.3.12	Demonstrate ORB processing to generate stimuli commands to the Payload and provide interface status. The payload shall respond with appropriate data.	Demonstrate ORB/Payload interface status data.
2. Verify the capability (including Backup Flight System) to monitor data from attached payloads.	Vol. XVIII, Bk 1, Para. 3.1.14, 3.2.7, 3.3.13, 3.5.7	Demonstrate onboard display and downlink by processing Payload data.	Demonstrate data as required by the ICD for a specific payload.
3. Verify the capability to perform payload checkout tests.	Vol. XVIII, Bk 1, Para. 3.1.12, 3.3.14	Verify that the Orbiter can detect payload system faults by performing test programs and processing payload data.	Demonstrate test programs, if any, required by the ICD for a specific payload.
4. Verify the capability (including Backup Flight System) to monitor and process data from attached payloads during flight.	Vol. XVIII, Bk 1, Para. 3.4.21, 2.4.22, Vol. X, Bk 1, Para. 3.3.1.3.3.5.5	Verify ORB processing of Payload data in a simulated flight environment.	Demonstrate data as required by the ICD for the specific payload.

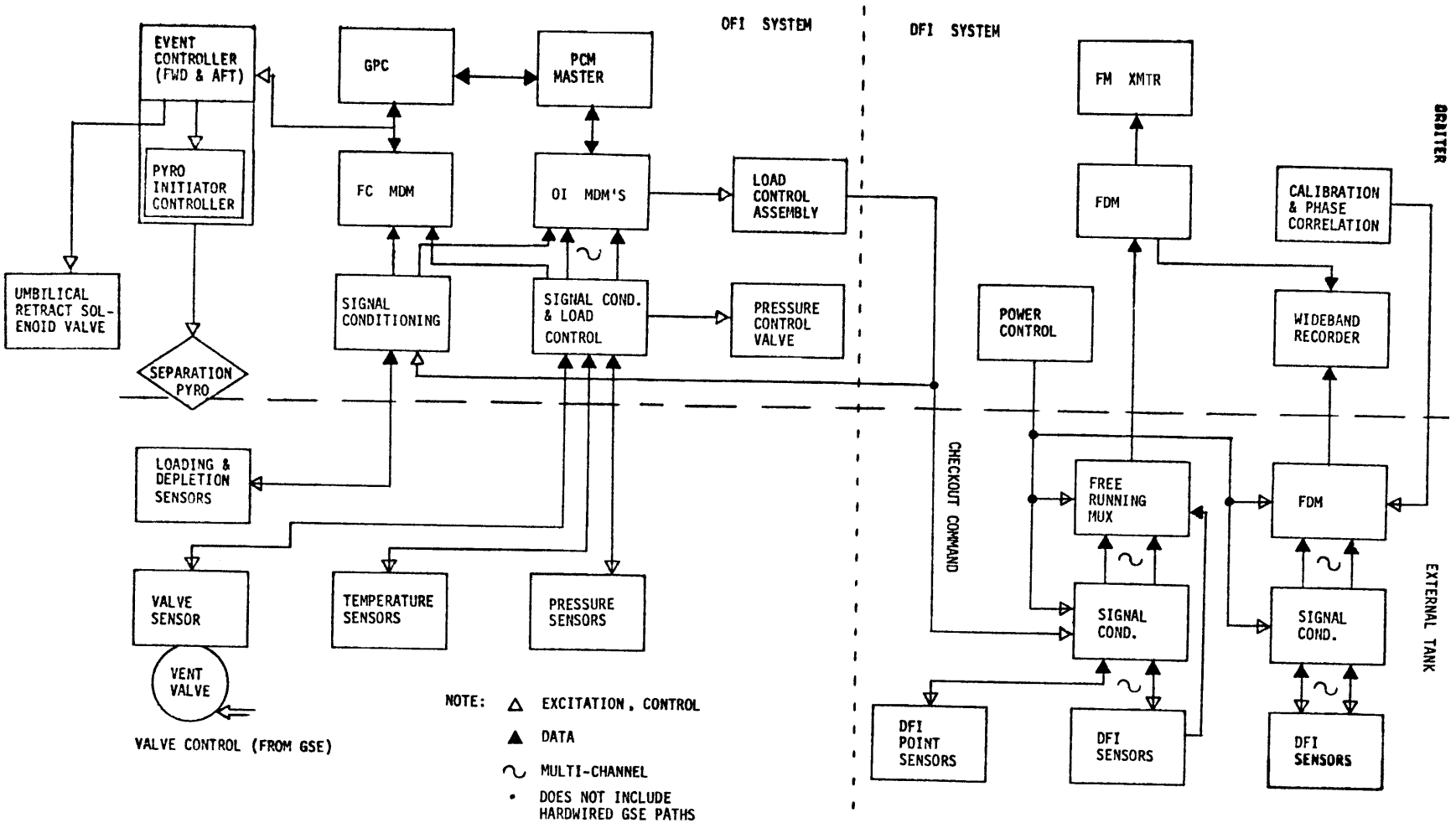
TABLE 4.5

ORBITER/PAYLOAD VERIFICATION REQUIREMENTS – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION	ACCEPTANCE CRITERIA
5. Verify the capability to perform payload initialization during flight.	Vol. XVIII, Bk 1, Para. 3.4.23, Vol. X, Bk 1, Para. 3.3.1.3.3.5.2	Verify ORB generation of Payload initialization data in a simulated flight environment.	Demonstrate payload initialization.
6. Verify the capability for command and control between the ORB and payload during flight.	Vol. XVIII, Bk 1, Para. 3.4.24, Vol. X, Bk 1, Para. 3.3.1.3.3.5.2, 3.3.1.3.3.5.5	Demonstrate payload generated attitude reference data and Orbiter attitude control.	Demonstrate integrated attitude control and desired payload pointing accuracy.

FIGURE 4–1

ORBITER/ET FUNCTIONAL INTERFACE



NOTE: For MADS Configured Vehicles, refer to Appendix B.

FIGURE 4–2

SIMPLIFIED BLOCK DIAGRAM OPERATIONAL FLIGHT CONFIGURATION

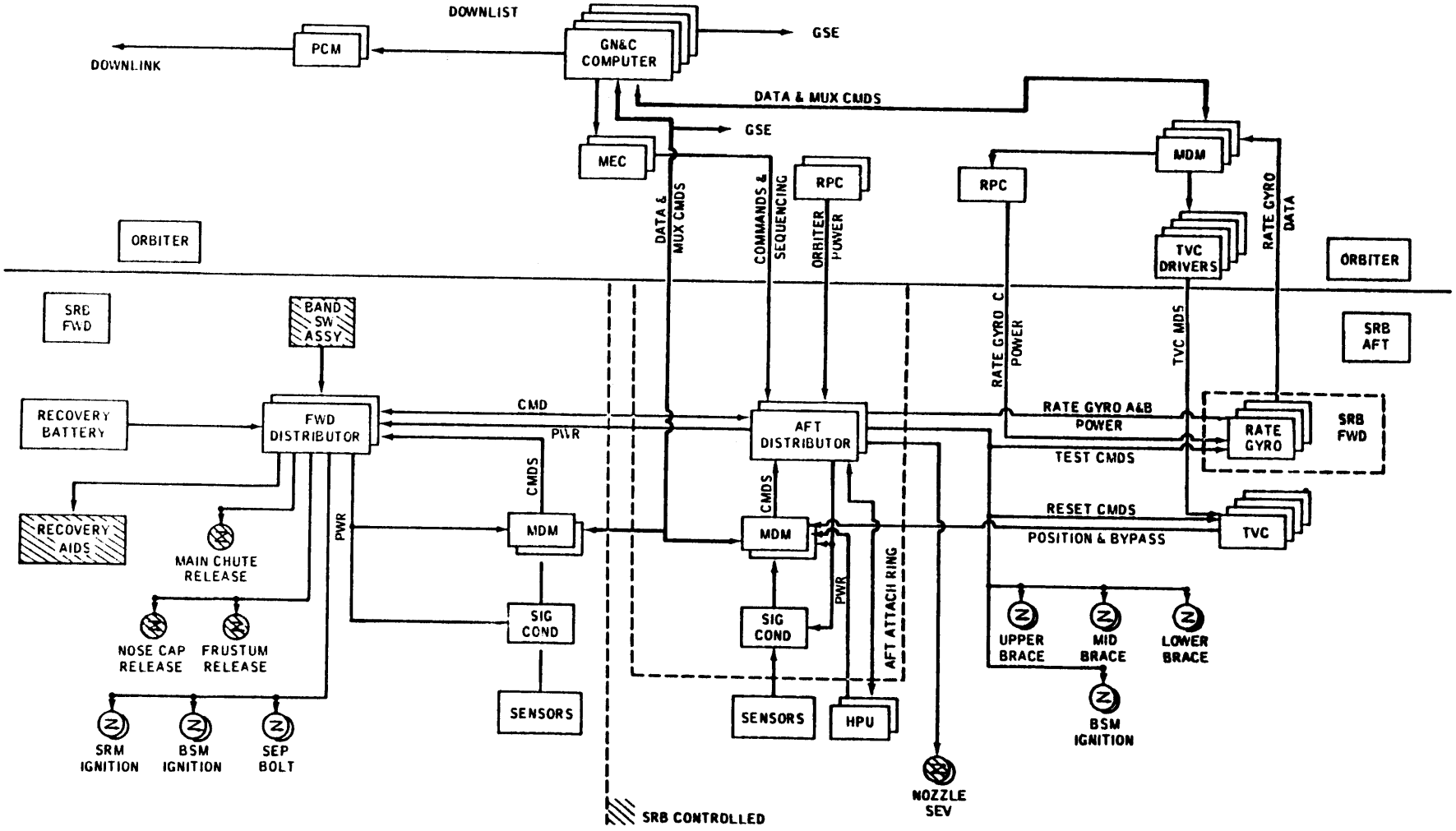


FIGURE 4–3

ORBITER/MAIN ENGINE COMPUTER SYSTEMS INTERFACE (PER ENGINE)

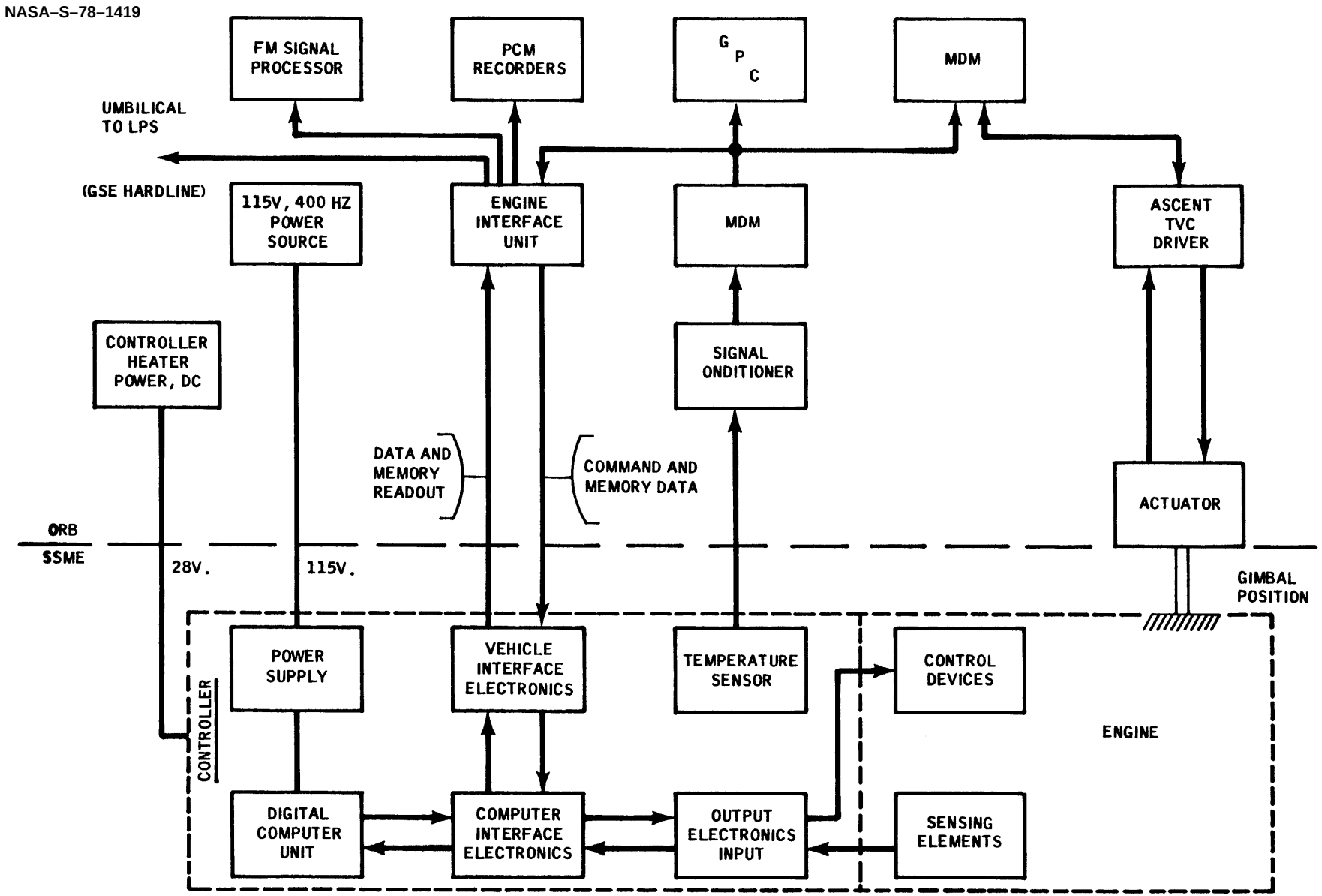


FIGURE 4–4

FUNCTIONAL DIAGRAM OF THE ORBITER INTERFACE TO SUPPORT NASA PAYLOADS

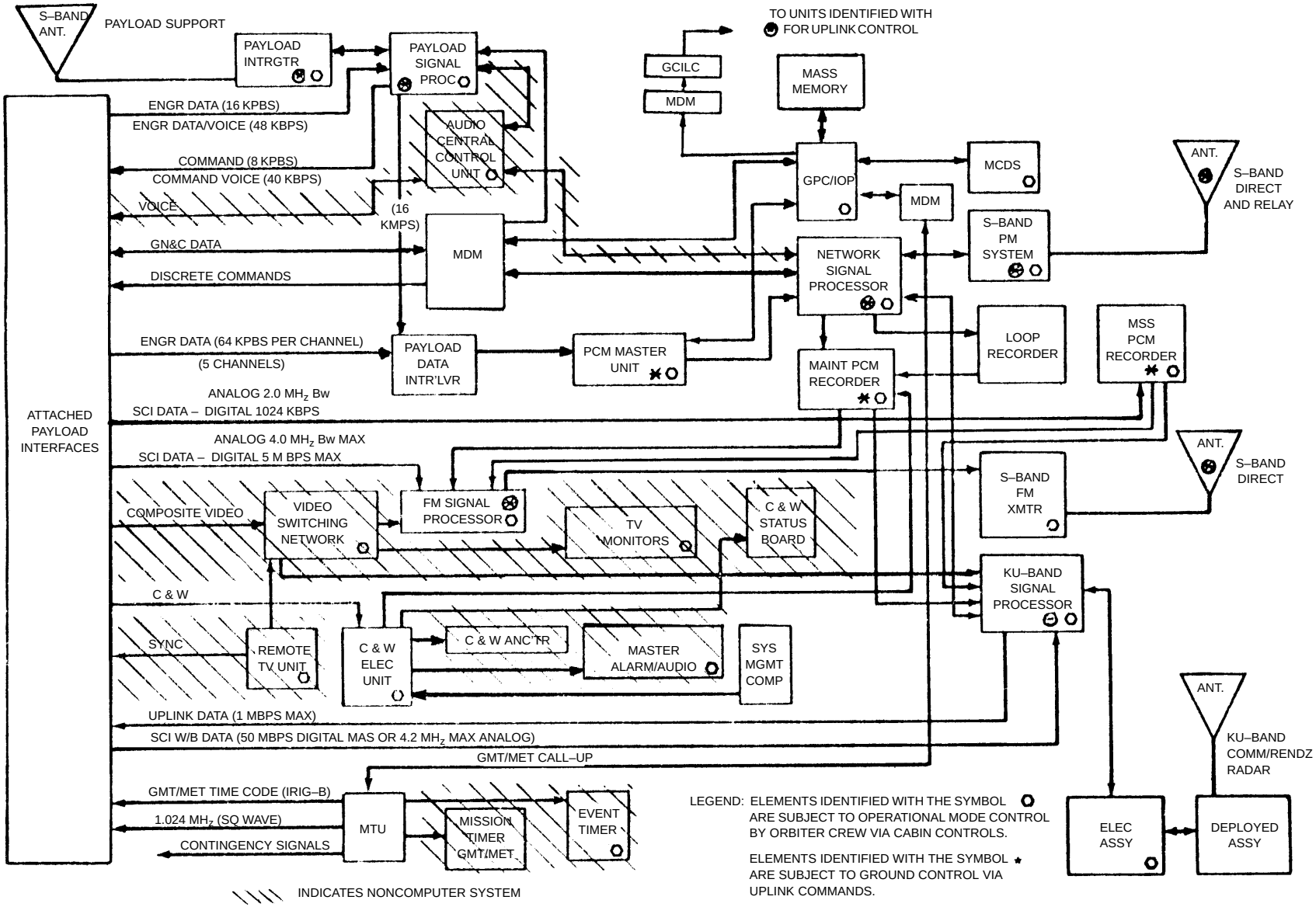
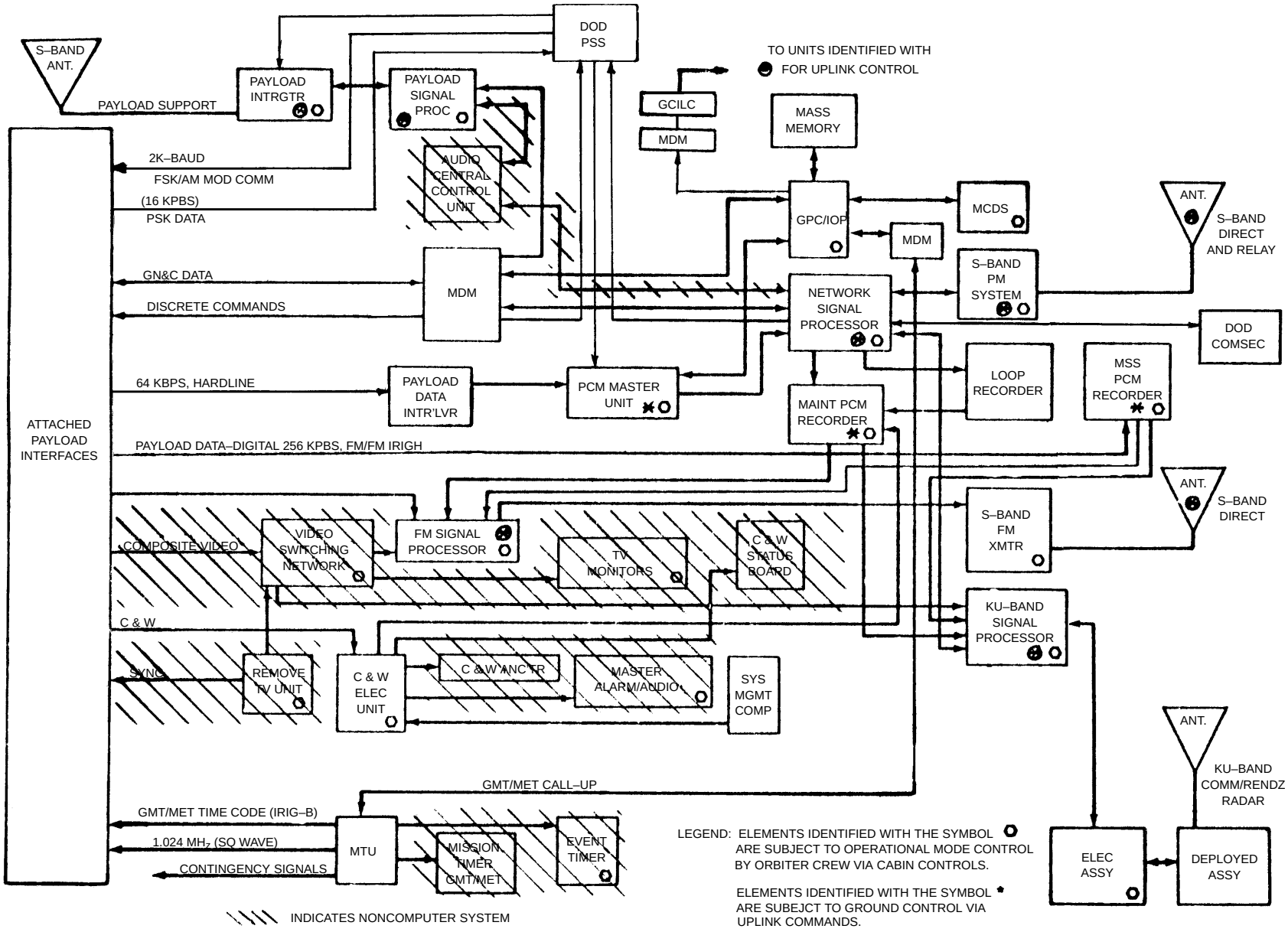


FIGURE 4–5

FUNCTIONAL DIAGRAM OF THE ORBITER INTERFACE TO SUPPORT DOD PAYLOADS



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5.0 GROUND OPERATIONS

This section defines verification requirements applicable to hardware/software interfaces between Space Shuttle elements and ground operations computer systems. Special emphasis is placed on verification of software functional compatibility among ground maintenance, checkout and launch control computer systems; flight computer systems; and mission and payload control computer systems. The primary source of these requirements is NSTS 07700, Volume XVIII, Bk 1, Section 3.0.

The interface verification requirements documented here were developed in accordance with the verification philosophy of Section 3.0.

Requirements for ground system/flight system interface verification presented in Paragraph 5.1 are organized by functional component string configuration, rather than by individual function. This organization permits formulation of requirements that assure verification of all component strings involved in handling ground/flight computer system communications, as well as other element–to–element communications that may be under control of a ground computer system.

Requirements for integrated computer system hardware/software verification are organized in terms of realtime integrated testing of operations and are presented in Paragraph 5.2.

Paragraph 5.3 contains a listing of verification requirements taken from Paragraphs 5.1 and 5.2 which are applicable to the specific test site listed.

5.1 FLIGHT VEHICLE TO GROUND INTERFACES

The flight vehicle to ground interface data formats, rate and content, as well as communications protocol, are determined by flight systems design. Interface requirements are imposed on Shuttle Program ground facilities by this design. This section lists verification requirements applicable to each of the flight vehicle to ground interfaces. The primary source for these requirements is NSTS 07700, Volume XVIII, Bk 1, Paragraph 3.3.8.

5.1.1 Launch Data Bus

The Launch Data Bus (LDB) is one link in the communications between the Orbiter data processing system and all applicable ground facilities for test, maintenance, and checkout as well as other preflight and post–flight operations. The following test requirements specify the type of tests and acceptance criteria for LDB operational verification. The approach used is to exercise the LDB in all its functional modes and verify that communications are successfully completed for each of these modes. Figure 5–1 shows the relation between these modes and the level at which messages are controlled for each mode.

5.1.1.1 General Purpose Computer (GPC) Communications

The Launch Data Bus provides the functional interfaces between the onboard GPC and the Ground Computer Complex (GND) for initialization, loading, and control of the following items in the Onboard Computational Facility:

Mass Memory Unit (MMU)
Test Software
Launch Sequence (LS)
Engine Interface Unit (EIU)
Master Events Controller (MEC)
Greenwich Mean Time Lift–Off (GMTLO) setting
Payload Serial Input/Output (SIO) handoff

The Test Software includes the Test Control Supervisor, both for sequences (TCS–S) and for single commands (TCS–1), and the Systems Software Avionics Command Support (SACS). Format and communications protocol for these interfaces are detailed in Sections 3, 4, 5, and 6 of CPDS SS–P–0002–150I.

Integration verification requirements for each of these functional interfaces are formulated in Table 5.1. This verification shall be performed under control of ground computer systems.

5.1.1.2 MDM Communications

The LDB provides a functional interface for commands and data between the GND and selected vehicle subsystems when the GPC is not active. This interface is via the ORB Command Decoder (CD) MDMs and the SRB MDMs. Format and communications protocol for these interfaces are detailed in Sections 7 and 8 of CPDS SS–P–0002–150I.

Integration verification requirements for these functional interfaces are formulated in Table 5.2.

5.1.2 Other Orbiter Umbilical Interfaces

The LDB is the primary interface between ground and vehicle computational facilities. There are, however, other hardline interfaces that carry Development (DFI) and Operational (OFI) Flight Instrumentation data, as well as a limited command capability for specific subsystems. This section specifies requirements for verification of functional integrity of those hardline interfaces which connect GND computational facilities to the following subsystems:

a. Engine Interface Unit

b. Master PCM Unit – OFI

c. PCM Loop and Maintenance Recorders

d. Network Signal Processors

e. Master PCM Unit – DFI

f. DFI PCM Recorders

g. DFI Wideband Recorders

h. DFI Wideband FDM

i. Payload Signal Processor

j. Payload Interrogator

k. Payload Recorder

Verification requirements for these interfaces are listed in Table 5.3. (Reference Appendix B for all MADS Configured Vehicles.)

5.1.3 Solid Rocket Booster Interfaces

Command, data, and DFI interfaces between the SRBs and ground computational facilities shall be tested and verified in accordance with requirements listed in Table 5.4.

5.1.4 External Tank Interfaces

Command, data, and DFI interface between the ET and ground computational facilities shall be tested and verified in accordance with requirements listed in Table 5.5.

5.1.5 (Deleted)

5.2 INTEGRATED COMPUTER SYSTEMS HARDWARE/SOFTWARE REALTIME VERIFICATION TEST REQUIREMENTS

This section defines realtime hardware/software verification test requirements to determine operational readiness of interfacing Shuttle elements for ground checkout and operations.

Paragraph 5.2.1 below specifies verification of the Orbiter/Vehicle Automated Checkout (VAC) integrated system at Palmdale. The remaining paragraphs in 5.2 specify verification of various Shuttle/LPS integrated systems at KSC.

5.2.1 Orbiter Integrated Checkout

Verify the capability to perform Orbiter integrated checkout which verifies the functional and performance operation of the Orbiter.

Verify that the Orbiter can:

a. Accept stimuli from the ground systems and can provide data to the ground systems.

b. Perform selected Orbiter preflight tests, flight modes and monitoring of system performance data.

Demonstrate that the ground system can select Orbiter preflight tests and flight modes to be performed by the Orbiter, can provide test stimuli and can monitor test data.

The Orbiter Integrated Checkout (OIC) will be used to verify the capability to perform the test. Objectives of the OIC are:

a. Demonstrate the compatibility of the Orbiter Vehicle subsystems when they are configured and operating in flight modes.

b. Verify the functional and performance operation (including backup modes) of Orbiter end item and the interaction between the subsystems in a simulated vertical flight. Approved and functionally certified simulators may be used at unmated interfaces.

c. Checkout will be oriented to manned Orbiter operation.

d. Determine that there are no EMI generated anomalies.

e. Verify “plugs out” configuration integrated checkout from simulated lift–off. This means the vehicle will be partially isolated from “earth ground”, R–F up and downlink via isolated hats and GSE/vehicle electrical/mechanical interface via dielectric isolation, DC blocks or transformer isolation to minimize conductive EMI and GSE ground loops.

f. Verify proper operation of systems or absence of sneak circuits as a result of umbilical or other Orbiter/interface connections by performing disconnect functions in mission time line sequence.

5.2.2 Orbiter Systems Verification

This section establishes requirements to verify the capability of the ground systems to conduct checkout of the integrated Orbiter. Verification of these capabilities will be required for activation of each ground facility which processes the Orbiter including operations supporting the orbital flight test program. The test capability to be verified will provide realtime verification of Orbiter and ground hardware and software. Approved and functionally certified simulators shall be used at unmated interfaces.

The tests used to verify the checkout capability are those used to verify Orbiter systems and flight element interfaces. Objectives of the tests are:

a. Verify functioning of the available flight element interfaces.

b. Verify subsystems functional operation utilizing end–to–end functional paths.

c. Isolate failures to the Line Replaceable Unit (LRU) level or group of LRUs.

d. Verify the combined subsystems functional performance.

e. Verify each primary function, backup mode, and redundant path.

The remainder of this section has been divided into four subsections to provide traceability to Space Shuttle Program software requirements.

5.2.2.1 Orbiter Systems/Subsystems Testing

Verify the capability to test Orbiter systems/subsystems to determine their operational status.

Determine that the Orbiter can perform selected Orbiter systems/subsystems tests for failure detection. The tests shall exercise all redundant paths. Provide testing to show that the Orbiter can provide data to the ground system and can transfer ground system generated stimuli commands to Orbiter systems/subsystems.

Verify that the ground system can select and command the operations of the Orbiter and monitor the resultant data, including providing stimuli commands where appropriate.

5.2.2.2 Orbiter Systems Fault Isolation

Verify the capability to isolate detected Orbiter system/subsystem failures to a functional path and to an LRU level or group of LRUs.

Verify that the Orbiter has the capability of isolating failures to a functional path level and operating such programs as are required to generate fault isolation stimuli and data.

Verify that the ground system can command the fault isolation operations, provide stimuli, and process data to isolate failures to an LRU or group of LRUs.

5.2.2.3 Orbiter/SSME Interface Testing

Verify the capability to test the command and data interface between the Orbiter and the SSME. These tests shall consist of tests selected from those tests specified in Paragraph 4.3.

Testing must demonstrate that the Orbiter can accept commands and execute programs to generate stimuli commands to the SSME and to monitor the SSME data

response and functional status. Show that the Orbiter is capable of providing command and data interface status to the ground system to monitor and control the process.

Verify that the ground system can command ORB/SSME interface test programs and monitor status data from the Orbiter to demonstrate that the ORB/SSME command and data interface is functional.

5.2.2.4 Orbiter/Payload Interface Testing

Verify the command and data interface between the Orbiter and payload(s) for payload(s) installed in the Orbiter. These tests shall consist of tests selected from those tests specified in Paragraph 4.4 consistent with installed payload(s) ICD(s).

Perform test programs to validate that the Orbiter can execute selected programs for ORB/PLD interface testing to generate stimuli commands to the payload and monitor payload data response. Ascertain that the Orbiter is capable of supplying the ground system with the ORB/PLD status data for controlling and monitoring the process.

Verify that the ground system can command the Orbiter programs for ORB/PLD interface testing and to monitor status as provided by the Orbiter.

Where the payload is not mated in the Orbiter Maintenance and Checkout Facility, verify the capability that the Orbiter systems are serviceable and ready for Orbiter mating with payload interfaces.

5.2.3 Orbiter Integrated Test

Verify the capability to perform integrated Orbiter tests which verify that Orbiter systems are serviceable and ready for Orbiter electronic mating with the ET and SRB interfaces.

Verify that the Orbiter can perform the selected Orbiter integrated systems tests and monitoring of system performance data including acceptance of stimuli from the ground systems and can provide data to the ground systems.

Demonstrate that the ground systems can select integrated systems test programs to be performed by the Orbiter monitor test data and provide supplemental test stimuli.

The Orbiter Integrated Test (OIT) will be used to verify the capability to perform the test. Objective of the test is:

> Verify the functional and performance operation (including Backup Flight System) of Orbiter end item and the interaction between the subsystems in a simulated mission sequences (including abort modes). Simulators may be used at unmated interfaces.

5.2.4 Shuttle Integrated Checkout

This section establishes requirements to verify the capability of the ground systems to conduct checkout of the integrated Shuttle. Verification of these capabilities will be for support of the Orbital Flight Test Program. The test capability to be verified will provide realtime verification of the Shuttle and ground hardware and software.

The tests used to verify the ground/Shuttle checkout capability will be those tests used for checkout of the integrated Shuttle. The objectives of the tests are:

a. Verify functioning of any newly mated flight element interfaces.

b. Verify compatibility of any Shuttle Systems involving the new flight element interfaces.

c. Verify the functional and performance operation (including Backup Flight System) of the Shuttle in a simulated mission timeline sequence.

d. Verify “plugs out” configuration integrated checkout from simulated lift–off.

5.2.4.1 Remote Orbiter Systems Control

Verify the capability to remotely control selected Orbiter systems configurations and modes of operation.

Demonstrate that the Orbiter can control selected Orbiter systems to support ground operations.

Verify that the ground system can command remote control of selected Orbiter systems as required to perform Orbiter tests.

5.2.4.2 Orbiter/ET Interface Testing

Verify the capability to test and verify the data interface between the Orbiter and the ET. These tests shall consist of tests selected from those in Paragraph 4.1.

Demonstrate the Orbiter’s capability to accept ground commands and execute programs to generate stimuli to the ET and monitor/transfer ET data for verification of the Orbiter/ET data interface.

Verify the capability of the ground facility to command Orbiter programs and generate stimuli commands for Orbiter/ET interface testing and to monitor status data from the Orbiter to verify the Orbiter/ET data interface.

5.2.4.3 Orbiter/SRB Testing

Verify the capability to test and verify the command and data interface between the Orbiter and the SRBs. These tests shall consist of tests selected from those tests specified in Paragraph 4.2.

Show the Orbiter's capability to accept ground commands and execute programs to generate stimuli commands to the SRB thrust vector controls and generate other interface commands, and to monitor SRB data for verification that the interface is functional.

Demonstrate that the ground system can command the Orbiter programs and generate stimuli commands for Orbiter/SRB interface testing and to monitor status data from the Orbiter to verify the Orbiter/SRB command and data interface.

5.2.4.4 Shuttle Integrated Test

Verify the capability to perform integrated Shuttle tests which verify that the Shuttle Systems are flight ready. Verify that the Orbiter is capable of performing selected Shuttle Systems tests and monitoring of system performance data, including acceptance of stimuli from the ground systems and the providing of data to the ground systems.

Demonstrate that the ground systems can select integrated systems test programs to be performed by the Orbiter and monitor test data. Supplemental test stimuli will be provided.

5.2.5 Payload Integrated Testing

Verify the capability to perform integrated payload testing to verify the data interface between the payload, the Orbiter systems, and the ground systems, and that the payload is ready for flight. General payload requirements are specified in Tables 4.5, 5.1 and B5.3.

5.2.5.1 (Deleted)

5.2.5.2 Payloads

Verify that the Orbiter is capable of performing selected payload tests, monitoring of system performance data, and accepting commands from the ground systems in accordance with unique interface requirements specified in payload specific ICDs and NSTS 21000–A04, Command and Data (reference Paragraphs 4.4.2, 4.4.3 and 4.4.4).

5.2.5.3 Inertial Upper Stage

Verify that the Orbiter is capable of performing selected IUS tests, monitoring of system performance, accepting commands from the ground systems and providing data to the

ground systems in accordance with the unique interface requirements specified in ICD D–E0001 (basic) and ICD D–E0001 (payload specific).

5.2.6 Prelaunch Testing

This section establishes requirements to verify the capability of the ground systems to conduct prelaunch testing and control of the Shuttle System. The test capability to be verified will provide verification of Shuttle/launch site interface, propellant loading support, and final countdown and launch operations. In support of Orbital flight test, the additional capabilities will be verified to simulate propellant loading, conduct payload compatibility tests, verify SSMEC interface and conduct the Flight Readiness Firing (FRF).

The tests needed to verify the prelaunch capability are those tests and simulated operations which are required for operational launch support plus additional testing required for the first orbital flight. The objectives of these tests and operations are:

a. Verify functioning of the Shuttle/launch pad interface.

b. Verify the functional operation of the Shuttle in a simulated flight consistent with the ground environment and capabilities.

c. Establish a Shuttle System status in preparation for launch.

d. Control propellant loading and support other hazardous servicing operations.

e. Demonstrate a 24 hour hold capability.

5.2.6.1 Shuttle/Launch Pad Interface Test

Verify the capability to test and verify the command and data interface between the Orbiter and launch pad as specified in ICD 2–0A002.

Provide testing to demonstrate that the Orbiter can accept commands and return command status and data to support functional verification of the Shuttle/launch pad/launch control interface.

Verify that the ground system is capable of issuing commands to the Orbiter and of processing data returned from the Orbiter to verify the functional status of the Shuttle/launch pad/launch control interface.

5.2.6.2 Plugs In Test

Verify the capability to establish Shuttle/ground systems readiness for launch operations by selected systems testing and fault isolation.

Re–verify Orbiter/payload interface testing capability by repeating the tests of Paragraph 5.2.2.4 in the launch pad environment.

Verify that the Orbiter can perform selected Shuttle Systems tests for failure detection, by exercising all redundant paths and isolating failures to a functional path level. Demonstrate the Orbiter's capability to generate fault isolation stimuli, to transfer ground generated stimuli commands to the Shuttle Systems and to provide data to the ground systems.

Show that the ground system can select and command the operations of the Orbiter, and can provide stimuli commands where appropriate. Provide evidence that the ground system is capable of monitoring the resultant data and processing data to isolate failures to an LRU or group of LRUs.

5.2.6.3 Plugs Out Test

Verify the capability to perform integrated Shuttle tests which verify that the Shuttle Systems are serviceable. These tests are similar to the Orbiter integrated tests, Paragraph 5.2.3.

Demonstrate the capability of the Orbiter to perform selected Shuttle integrated systems tests and to monitor system performance data. Show that the Orbiter can accept stimuli from the ground systems and provide data to the ground systems.

Verify the the ground systems can select integrated systems programs to be performed by the Orbiter and monitor test data. Demonstrate that the commanded programs can be selected so as to demonstrate performance in simulated mission sequences. The stimuli and resultant mission sequences must be consistent with launch pad capabilities.

5.2.6.4 MCC/Orbiter Interface Test

Verify the capability to perform the MCC/Orbiter interface test to support the functions that will be used during prelaunch and launch operations. These functions include mission targeting or retargeting, mass properties updates, launch command and control, mission control functions and other functions specified in ICD 2–0D004.

Demonstrate that the Orbiter can accept uplink data and commands, can provide related computational capability, and transfer updated data to the payload computers or SSMEs and can provide downlink data.

Show that the ground systems can support the MCC interface test and verify the TBD interface between the ground systems and the MCC.

Verify the MCC capability to support the interface test. Demonstrate the ability to load the parameters via uplink during prelaunch. Verify the MCC capability to receive via

downlink and process Shuttle Vehicle telemetry which will support prelaunch operations and will establish Mission Control Center readiness for transfer of control following lift–off.

5.2.6.5 Wet Countdown Demonstration Test

Verify the capability to conduct the wet countdown demonstration test. The test will verify that the Shuttle main propulsion system is ready for launch and will develop confidence in the countdown procedures.

Verify that the Orbiter can monitor propellant data and provide the data to the ground system, including its ability to accept and process commands to establish an active status for firing.

Demonstrate that the ground system can control propellant loading and can issue commands to implement a launch countdown sequence including the processing of propellant data to support loading operations.

5.2.6.6 Flight Readiness Firing

Verify the capability to perform the FRF.

Upon completion of a countdown sequence, show that the Orbiter can command a FRF test with an interlock from the ground system. Demonstrate the Orbiter's ability to monitor Shuttle Systems data and provide data to the ground system.

Verify that the ground system can determine completion of the countdown sequence, provide safety interlocks and monitor Shuttle Systems data.

5.2.6.7 Dry Countdown Demonstration Test (CDDT)

Verify the capability to conduct a dry CDDT. The test will verify integrity of the Shuttle main propulsion system and will develop confidence in the countdown procedure.

Demonstrate that the Orbiter can provide data to the ground system, including the acceptance and processing of commands to establish a simulated status for firing.

Validate that the ground system can issue commands to implement a simulated launch countdown sequence and can process system data.

5.2.6.8 Launch Readiness Verification

Verify the capability to perform launch readiness verification.

Show that the Orbiter is capable of performing selected Shuttle Systems flight readiness test programs and monitoring Shuttle Systems performance.

Verify that the ground system can select and command the Orbiter to accomplish test programs and can monitor Shuttle Systems status.

5.2.6.9 Safety Servicing

Verify the capability to support safety servicing of the Shuttle Vehicle.

Validate the Orbiter's capability to accept ground commands, generate other Shuttle System commands and provide data to the ground system for monitoring vehicle systems configuration and status.

Demonstrate that the ground system is capable of generating commands to control Shuttle Vehicle configurations in support of propellant loading and of processing the data required to monitor the process.

5.2.6.10 Countdown

Verify the capability to perform the terminal countdown and launch command and control prior to lift–off.

Verify that the Orbiter can synchronize with launch control and mission control during the terminal launch countdown process. The Orbiter shall generate and issue the commands for safe and arm, motor positioning and then generate and issue SSME and SRB start commands subject to ground system interlocks.

Demonstrate that the ground system is capable of controlling the Ground System, the terminal launch countdown process, including commanding the SSME (except for the start command). Show that it can prevent SSME and SRB start commands through an interlock where potential violation of mission rules or vehicle safety requires such action and demonstrate that it can provide for commanding SSME shutdown in the event SRB start is inhibited. Verify that the ground can control SSME sequencing via the GPC to SSMEC interface for aborted missions on the pad.

5.3 FACILITY PECULIAR INTERFACES

The various phases of ground operations involved in Space Shuttle Vehicle receiving, assembly, checkout, launch and turnaround coupled with the diversity of elements that make up the flight vehicle require the operation of specialized facilities which are either element or operation peculiar. Each of these facilities must be integrated with its corresponding element or integrated group of elements according to the ground task to be performed at that facility. This section covers computer systems and software verification requirements for KSC, Palmdale, Edwards AFB (EAFB), and Vandenberg AFB. These requirements are arranged so as to indicate which of the interfaces covered in

Section 5.1, and which of the integrated tests covered in Paragraph 5.2 are applicable. Specific verification requirements peculiar to a facility and test combination are listed only where deviations from the above requirements are indicated.

5.3.1 Kennedy Space Center

The various processing, maintenance, and checkout facilities at KSC for the Space Shuttle Program are discussed below in terms of computer systems and software verification requirements. Some of these facilities use a totally independent launch processing system equipment complex, while others are connected to the Shuttle Data Center (SDC). The SDC provides data processing services for LPS command and control support and data display, as well as batch and time–sharing operations for KSC engineering. The relationship between each facility or station to the LPS is also indicated in the following sections.

5.3.1.1 Hypergolic Maintenance And Checkout Station

The hardware/software integration verification requirements for this station are primarily intended to verify that the station set is ready to accept, and properly interface with one set of hypergolic propulsion modules. The specific verification requirements are defined in ICD 2–1A003.

The LPS supports the automatic engine checkout by controlling and monitoring Ground Support Equipment (GSE), facilities, and SSME system; and by providing data processing and display functions. The LPS will also have the capability to load, readout, and verify SSME controller memory.

The LPS interfaces directly with the SSME controller to achieve the verification and checkout activities listed above. This interface shall be verified in accordance with the requirements indicated in Paragraph 5.1.5 of this document.

5.3.1.2 (Deleted)

5.3.1.3 Spacelab Processing Facility

Configuration and verification requirements for this facility are contained in Spacelab/ Payload Specific NSTS 21000–A08, Launch Site Support Plan [K–STSM–11.0 (Horizontal Payload)].

5.3.1.4 IUS Processing Facility

Configuration and verification requirements for this facility are contained in IUS/Payload Specific NSTS 21000–A08, Launch Site Support Plan [K–PSM–11.01 (Deployable Payload)], in ICD D–E0001 (basic) and in ICD D–E0001 (payload specific).

5.3.1.5 Orbiter Processing Facility

The Orbiter Processing Facility (OPF) contains the equipment and consumable drainage and supplies to receive, safe, inspect, refurbish, prepare and checkout the Orbiter for a given mission. This is the facility where the Orbiter integrated test is performed to verify Orbiter flight readiness. Verification requirements for this test are as indicated in Paragraph 5.2.3. Functional and physical interfaces are defined in ICD 2–1A002. Verification requirements for each of the Orbiter–to–Ground interfaces exercised at this facility are as indicated in the following sections of this document:

Interface	Requirement
Launch Data Bus	Paragraph 5.1.1
Engine Interface Unit	Table 5.3, Item 1
Master PCM Unit – OFI	Table 5.3, Item 2
PCM Loop and Maintenance Recorders	Table 5.3, Item 3
Network Signal Processor	Table 5.3, Item 4
Master PCM Unit – DFI	Table 5.3, Item 5
DFI PCM Recorder	Table 5.3, Item 6
DFI Wideband Recorder	Table 5.3, Item 7
DFI Wideband FDM	Table 5.3, Item 8
Payload Signal Processor	Table 5.3, Item 9
Payload Interrogator	Table 5.3, Item 9

Interfaces between the Orbiter and ground facilities used to verify ORB/ET (ICD 2–12001), ORB/SRB (ICD 2–14001), ORB/SSME (ICD 13M15000), and ORB/PLD (Payload Specific ICD) interfaces shall be verified in accordance with requirements in the following sections:

Interface	Requirement
ORB/ET Interface	Paragraph 4.1
ORB/SRB Interface	Paragraph 4.2
ORB/SSME Interface	Paragraph 4.3
ORB/PLD Interface	Paragraph 4.4

(Reference Appendix B for all MADS Configured Vehicles.)

5.3.1.6 ET Processing and Storage Station

This station set includes the facilities and equipment required to process the ET from its arrival at KSC through checkout, storage, and transfer of the ET to the VAB. The LPS

supports these activities by controlling and monitoring GSE, facilities, and ET systems, and providing data processing and display functions. There is no actual computer system onboard the ET; however, verification of the ET interfaces, as specified in ICD 2–2A001, with the Ground computer systems shall be accomplished in accordance with the requirements of Paragraph 5.1.4.

5.3.1.7 SRB Processing and Storage Station

This station includes the equipment and facilities for receipt, storage, and assembly of the nose cone, aft skirt systems, solid rocket motor, and SRB segments. An LPS station set, not connected to the SDC, will support these activities by controlling and monitoring GSE, facilities, and SRB systems, and by providing data processing and display functions. As in the ET, there is no actual computer system onboard the SRB; however, verification of the SRB interfaces with ground computer systems shall be accomplished in accordance with the requirements of Paragraph 5.1.3.

5.3.1.8 SRB Retrieval And Disassembly Station

This station provides capabilities for locating the SRB after splashdown, recovering all recoverable items, disassembling as required for transportation, fresh water washdown, decontamination and cleaning, and subsequent transportation of assembled SRB or individual segments to the vendor.

There are no computer system interfaces between the SRB and the facility. Interfaces at this station are primarily mechanical, therefore no computer systems and software verification requirements are applicable to this station.

5.3.1.9 Shuttle Vehicle Assembly and Checkout Station

This station consists of the High Bay transfer aisle and High Bays 1 and 3. This is the location where SRBs, ET, and Orbiter are mated following final maintenance and preparation for mate. Interface verification in preparation for mating shall be performed in accordance with verification requirements in Paragraph 5.1.3 for SRBs and Paragraph 5.1.4 for the ET.

Mating of Shuttle Vehicle elements is done on the Mobile Launcher Platform (MLP). Shuttle checkout on the MLP will be limited to that required to verify the interface compatibility between elements and between the Shuttle Vehicle and ground equipment. Verification of functional integrity of each of these interfaces shall be performed in accordance with the requirements in the corresponding section of this document as indicated below:

Interface	Requirement
Launch Data Bus	Paragraph 5.1.1
Engine Interface Unit	Table 5.3, Item 1
Master PCM Unit – OFI	Table 5.3, Item 2
PCM Loop and Maintenance Recorders	Table 5.3, Item 3
Network Signal Processors	Table 5.3, Item 4
Master PCM Unit – DFI	Table 5.3, Item 5
DFI PCM Recorder	Table 5.3, Item 6
DFI Wideband Recorder	Table 5.3, Item 7
DFI Wideband FDM	Table 5.3, Item 8
Payload Signal Processor	Table 5.3, Item 9
Payload Interrogator	Table 5.3, Item 9
SRB Tail Plug	Paragraph 5.1.3
ET FM Multiplexer	Paragraph 5.1.4

(Reference Appendix B for all MADS Configured Vehicles.)

5.3.1.10 Launch Pad Station

This station requires the most complete set of interfaces between ground computational systems and the Space Shuttle Vehicle. Verification of functional integrity of each of these interfaces shall be performed in accordance with the requirements in the corresponding section of this document as indicated below:

Interface	Requirement
Launch Data Bus	Paragraph 5.1.1
Engine Interface Unit	Table 5.3, Item 1
Master PCM Unit – OFI	Table 5.3, Item 2
PCM Loop and Maintenance Recorders	Table 5.3, Item 3
Network Signal Processors	Table 5.3, Item 4
Master PCM Unit – DFI	Table 5.3, Item 5
DFI PCM Recorder	Table 5.3, Item 6
DFI Wideband Recorder	Table 5.3, Item 7

DFI Wideband FDM	Table 5.3, Item 8
Payload Signal Processor	Table 5.3, Item 9
Payload Interrogator	Table 5.3, Item 9
Payload Recorder	Reference Payload Specific ICD and the MML. Reference Para. 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5
SRB Tail Plug	Paragraph 5.1.3
ET FM Multiplexer	Paragraph 5.1.4

Shuttle integrated tests shall be performed at the launch pad station in accordance with the verification requirements for prelaunch testing as indicated in Paragraph 5.2.6. (Reference Appendix B for all MADS Configured Vehicles.)

5.3.2 Palmdale Factory Checkout Facility

The primary computational interface between ground VAC equipment and the Orbiter is the launch data bus. Ability to conduct VAC/ORB communications on the LDB shall be verified in accordance with requirements stated in Paragraph 5.1.1.

Both OFI data and DFI data from the Orbiter are routed to VAC via a hardwire link at the T−0 umbilical. This interface shall be verified in accordance with Item B of Paragraph 5.1.2 and Table 5.3. (Reference Appendix B for all MADS Configured Vehicles.)

Acceptance criteria, specifications of interface performance, and configuration peculiar to Palmdale are contained in ICD 3−0607−01.

5.3.3 Edwards Air Force Base (EAFB)

Acceptance Criteria, Specification of Interface Performance and Configuration Peculiar to EAFB are contained in ICD−1D003 (IRN 081, reidentifies ICD 2−1D003 as Orbiter/ Landing and deservicing station for all landing stations except KSC [ICD 2−1A001]).

Reference is made to Paragraph 5.1.4 Data Systems Interface Tabulation, Paragraph 5.4.1 through 5.4.12 and Table 5.4, Orbiter Data Systems Interface of ICD 2−1D003 (reference Appendix B for all MADS configured vehicles).

5.3.4 Vandenberg Air Force Base (VAFB)

Verification requirements for Space Shuttle Systems to ground computational facility interfaces are (TBD).

5.3.4.1 Orbiter Systems/Hypergolic Servicing Facility (VAFB)

TBD

5.3.4.2 Orbiter/ORB Maintenance and Checkout Facility (VAFB)

TBD

5.3.4.3 External Tank/Tank Checkout Facility (VAFB)

TBD

5.3.4.4 SRB/SRB Receiving and Storage Facility (VAFB)

TBD

5.3.4.5 SRB/SRB Disassembly Facility (VAFB)

TBD

5.3.4.6 Space Shuttle/Launch Pad (VAFB)

TBD

5.3.4.7 Orbiter/Safing and Deservicing Facility (VAFB)

TBD

TABLE 5.1

GND TO GPC INTERFACE VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION CPDS SS–P–0002–150I	ACCEPTANCE CRITERIA CPDS SS–P–0002–150I
1. Verify proper loading, execution and control of TCS test sequences, including TCS error status generation and response.	Vol. XVIII, Bk 1, Para. 3.1.4, 3.2.3, 3.3.5, 3.5.4	Issue representative TCS test sequence, GND to GPC and monitor execution and status generation. Exercise control capabilities on sequence execution and verify correct status.	Format, time to respond, echo RHW, CHW, DWs, time tag where appropriate. Sequence load and call up ability from MMU and GPC memory. Proper TCS/ CALL program error response format and status content.
2. Verify proper TCS–1 command transmission, processing and response. (Including backup flight system).	Vol XVIII, Bk 1, Para. 3.1.4, 3.2.3, 3.3.5, 3.5.4	Issue representative TCS–1 commands, GND to GPC and verify proper response.	Format, time to respond, echo RHW, CHW, DWs, time tag where appropriate.
3. Verify proper SACS command transmission, processing and response. (Including backup flight system).	Vol XVIII, Bk 1, Para. 3.1.4, 3.2.3, 3.3.5, 3.5.4	Issue representative SACS commands, GND to GPC and verify proper response.	Format, time to respond, echo RHW, CHW, DWs, time tag where appropriate.
4. Verify capability to read and write on each Mass Memory Unit (MMU) and demonstrate accuracy of data transfer, including status request and response.	Vol XVIII, Bk 1, Para. 3.1.1, 3.2.1, 3.3.1, 3.5.1	Issue MM write command and verify proper data transfer by reading back through GPC for verification by GND. Issue MMU status request commands and verify proper response.	Format, time to respond, status information, ability to detect load or read errors, RHW, CHW, DWs time tag as appropriate.

TABLE 5.1

GND TO GPC INTERFACE VERIFICATION REQUIREMENTS – Continued

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION CPDS SS–P–0002–150I	ACCEPTANCE CRITERIA CPDS SS–P–0002–150I
5. Verify capability to load SSMEC memory and check accuracy of load.	Vol. XVIII, Bk 1, Para. 3.1.2, 3.3.2	Load SSMEC memory through GPC and dump back through EIU 60 Kbps hardline for verification by GND.	Format, time to respond, status information, ability to detect load errors.
6. Verify capability to control the terminal count execution in the GPCs with commands from GND.	Vol. XVIII, Bk 1, Para. 3.3.19	Issue representative sequence control and GMT lift–off time set commands from GND to GPCs, while GPCs execute terminal count sequence software in redundant set and verify proper response.	Format, time to respond, message acceptance/ rejection status, time tag, RHW, CHW.
7. Verify capability to transfer data from GND to payloads and payloads to GND through GPCs via the payload serial I/O handoff.	Vol. XVIII, Bk 1, Para. 3.1.12, 3.1.13, 3.1.14, 3.2.7, 3.3.12, 3.3.13, 3.3.14, 3.5.7	Verify that the Orbiter can process payload data from and to the ground during flight in a simulated flight environment. Reference Para. 5.3.28 (Payload Data) and Tables 5.1 and 5.2 of the specifications.	Demonstrate the processing of data, if any, required by the ICD and NSTS 21000– A04 for a specific payload.
8. Verify ability (including Backup Flight System) to conduct LDB communications on alternate LDB.	Vol. XVIII, Bk 1, Para. 3.5.1.1.3	Issue an LDB switchover command from the GND and repeat above items in this table for alternate LDB.	Ability to perform communications on either LDB.

TABLE 5.1

GND TO GPC INTERFACE VERIFICATION REQUIREMENTS – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION CPDS SS–P–0002–150I	ACCEPTANCE CRITERIA CPDS SS–P–0002–150I
9. Verify automatic LDB switchover capability in the GPC (including Backup Flight System).	Vol. X, Bk 1, Para. 3.5.1.1.2	Send invalid response to GPC and verify LDB switchover, then withhold response to interrogate command words from GPC and verify LDB switchover.	Time to accomplish switchover and integrity of communications following switchover.
10. Verify ability to switch to alternate GPC.	Vol. XVIII, Bk 1, Para. 3.1.4, 3.1.6, 3.2.3, 3.2.4, 3.3.5, 3.3.7, 3.5.4 and 3.5.6	Issue GPC switchover commands from the ground and verify proper execution of switchover to designated GPC.	Time to accomplish switchover and integrity of communications following switchover.

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TABLE 5.2

GND TO CD, SRB MDM VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION CPDS SS–P–0002–150I	ACCEPTANCE CRITERIA CPDS SS–P–0002–150I
1. Verify ability to issue GND to CD MDM and GND to SRB MDM commands and check for proper processing and response.	Vol. XVIII, Bk 1, Para. 3.1.6.2, 3.2.4.2, 3.3.7.2, 3.5.6.2	Issue representative commands to each CD and SRB MDM and monitor effect of command via PCM and/or LDB links as applicable.	Demonstrate format, time to respond, status information, accuracy of command response.
2. Verify ability to transfer GND to CD MDM and ground to SRB MDM data and check for accuracy of transfer.	Vol XVIII, Bk 1, Para. 3.1.6.2, 3.2.4.2, 3.3.7.2, 3.5.6.2	Transfer a representative set of data to each CD and SRB MDM and check accuracy of data transfer by monitoring applicable subsystem via PCM and/or LDB links as applicable.	Demonstrate format, status information, accuracy of data read, ability to detect transmission errors.
3. Verify ability to transfer CD MDM to GND and SRB MDM to GND data and check for accuracy of transfer.	Vol XVIII, Bk 1, Para. 3.1.6.2, 3.2.4.2, 3.3.7.2, 3.5.6.2	Issue a read data request to each CD and SRB MDM for previously determined data and check for accuracy of transfer.	Demonstrate format, status information, accuracy of data read, ability to detect transmission errors.

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TABLE 5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
1. Verify ability to monitor EIU and SSME performance.	Vol. XVIII, Bk 1, Para. 3.1.2 and 3.3.2	Issue commands to EIU and SSME system via LDB and read 60 Kbps EIU/GND hardlines for proper response, status, and parity per Section 5.0.	Data format, status content, and accuracy of transmission.
2. Verify ability to monitor SSV subsystems via PCMMU hardline interfaces, both the 128 and 64 Kbps links.	Vol. XVIII, Bk 1, Para. 3.1.3, 3.2.2, 3.3.3 and 3.3.10	Issue commands to PCMMU–1 to exercise the various formats available and monitor the hardline PCMMU links for proper response format and content per Section 4.0. Repeat for PCMMU–2.	Proper synch, frame and format identification, and downlist and downlink organization in accordance with specific reports of the DIP (JSC 18206).
3. Verify ability to monitor and control the PCM loop and maintenance recorders using hardline GND links.	Vol. XVIII, Bk 1, Para. 3.1.3, 3.2.2, 3.3.3, and 3.3.10	Issue commands to recorder–1 to record and then to dump via hardline data dump links to ground and monitor these lines for proper response, format and content per Section 6.0. Repeat for recorder–2.	Data format, content, accuracy of transmission as well as rate of recording and dump applicable to each recorder as indicated in Section 6.0.

(Reference Appendix B for all MADS Configured Vehicles.)

TABLE 5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES – Continued

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
4. Verify ability (including Backup Flight System) to communicate, uplink and downlink with each of the 2 redundant Network Signal Processors via hardline GND links.	Vol. XVIII, Bk 1, Para. 3.3.4, 3.3.18, 3.4.4	Issue uplink commands to OCF via NSP–1 and verify effect of command using PCM data from NSP–1. Repeat for NSP–2. Verify coded and uncoded commands and both high and low data rate modes per Section 7.0.	Proper synch, frame and format identification, data rates, and data content per Section 7.0.
5. Verify ability to monitor DFI for SSV subsystems via DFI–PCMMU hardline interfaces.	MVP Vol. I, Para. 3.4	Issue commands to DFI–PCMMU–1 to exercise the various formats available and monitor the hardline DFI–PCMMU for proper response format and content per Section 8.0. Repeat for DFI–PCMMU–2.	Proper synch, frame and format identification, and downlink organization in accordance with specific reports of the DIP (JSC 18206)
6. Verify ability to monitor and control the DFI PCM recorder using hardline GND links.	MVP Vol. I, Para. 3.4	Issue record and dump commands to DFI PCM Recorder via LDB and monitor hardline data dump link to ground for proper response, format, and content, both for continuously recorded and sample recorded data dump, per Section 9.0.	Data format, content, accuracy of transmission, and time of transmission interruption by track switching or data sample packing, per Section 9.0.

(Reference Appendix B for all MADS Configured Vehicles.)

TABLE 5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES – Continued

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
7. Verify ability to monitor and control the DFI Wideband recorder using hardline GND links.	MVP Vol. I, Para. 3.4	Issue record and dump commands to ascent recorder via LDB and monitor hardline data dump link to ground for proper response, format and content per Section 11.0. Repeat for [On–Orbit recorder].	Channel frequency deviation, pre–emphasis and formats in accordance with Section 11.0 and Tables 10.2.1–1, 14.2–1 and 15.2.2–1.
8. Verify ability to monitor DFI for SSV subsystems via DFI wideband FDM hardline interfaces.	MVP Vol. I, Para. 3.4	Issue commands to initiate DFI data downlink by each of the 3 DFI FDMs, and monitor the 5 outputs of each FDM for performance in accordance with Section 10.0.	Channel frequency deviation, pre–emphasis and formats in accordance with Tables 10.2.1–1 and 10.2.2–1.
9. Verify ability to monitor payload command data via the Payload Signal Processor and payload data via the Payload Data Interleaver and PCMMU hardline interfaces.	Vol. XVIII, Bk 1, Para. 3.1.14, 3.2.7 and 3.3.13	Issue command data from the GPCs and monitor via PSP–1 for proper response, format and content per Section 13.0. Issue simulated TM data via PSP–1 and monitor the hardline PCMMU links for proper response, format and content per Section 13.0 repeat for PSP–2.	Proper sync, frame and format identification and data rates.

(Reference Appendix B for all MADS Configured Vehicles.)

TABLE 5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
10. Verify ability to monitor payload data via the FM Signal Processor hard-line interfaces.	Vol. XVIII, Bk 1, Para. 3.1.3	Select signal sources and monitor the response, format and content per Section 12.0.	Proper sync, frame and format identification and data content.
11. Verify ability to monitor and control the payload recorder using hardline ground links.	Vol. XVIII, Bk 1, Para. 3.1.3	Issue commands to the Payload Recorder and then dump via hardline data dump links to the ground. Monitor for proper response, format and content per Section 17.0.	Data format, content and accuracy of transmission as well as rate of recording and dump as indicated in Section 17.0.

(Reference Appendix B for all MADS Configured Vehicles.)

TABLE 5.4

SRB TO GND VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
1. Verify ability to monitor DFI for SRB subsystems using the SRB PCM Multiplexer via tail plug interface.	Vol. XVIII, Bk 1, Para. 3.2.6	Monitor SRB DFI, via tail plug and verify that performance of PCM Multiplexer is per Section 15.2.1.	Channel frequency, deviation, pre–emphasis, rate and formats per Figure 15.2.1–1 and Table 15.2.1–1.
2. Verify ability to monitor DFI for SRB subsystems using the SRB FM multiplexer via tail plug interface.	Vol. XVIII, Bk 1, Para. 3.2.6	Monitor SRB DFI, via tail plug and verify that performance of FM Multiplexer is per Section 15.2.2.	Channel frequency, deviation, pre–emphasis, rate and formats per Table 15.2.2–1.
3. (Deleted)			
4. Verify ability to record and playback DFI data on SRB Flight Tape Recorder; under control of ground system.	Vol. XVIII, Bk 1, Para. 3.2.6	Issue record command to Flight Tape Recorder, playback, and compare data with that obtained via tail plug. Performance shall be per Section 15.2.4.	Data formats, length of recording and tape speed.

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TABLE 5.5

ET TO GND VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
1. Verify ability to monitor DFI for ET subsystems using the ET PCM output. Payload Data Interleaver and PCMMU hardline interfaces.	Vol. XVIII, Bk 1, Para. 3.2.5	Issue level sensor checkout commands to ET and read corresponding PCM data. Verify ambient readings for ET parameters. Communications characteristics shall be per Para. 14.1.	Proper sync, frame and format identification. Channel frequency and deviations per Table 14.1–1 and 14.2.1–1.
2. Verify ability to monitor DFI for ET subsystems using the ET FM Multiplex outputs.	Vol. XVIII, Bk 1, Para. 3.2.5	Issue FM Multiplexer checkout commands to ET and read corresponding data at the ET FM Multiplexer outputs. Performance shall be per Para. 14.2.	Channel frequency, deviation, pre–emphasis, rate and formats per Table 14.2–1.
3. Monitor OI for ET subsystems which are normally hardwired to Orbiter MDMs.	Vol. XVIII, Bk 1, Para. 3.2.5	Demonstrate that the GND can execute selected programs to perform ET tests and monitor ET data to determine ET operational status and detect failures after vehicle mate.	ET data is sufficient to verify proper ET performance.
4. Verify capability to control ET systems configurations and operational modes.	Vol. XVIII, Bk 1, Para. 3.2.8	Demonstrate that the GND can generate commands and the ET can execute the commands and provide appropriate data in response prior to vehicle mate.	ET data indicates systems configurations and operational modes are achieved as commanded.

TABLE 5.5

ET TO GND VERIFICATION REQUIREMENTS – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
5. Verify capability to perform ET subsystems, systems and integrated systems testing and performance monitoring.	Vol. XVIII, Bk 1, Para. 3.2.9, 3.2.10	Demonstrate that the GND can execute selected programs to perform ET tests and monitor ET data to determine ET operational status and detect failures prior to vehicle mate.	ET data is sufficient to verify proper ET performance.
6. Verify capability to conduct fault isolation procedures.	Vol. XVIII, Bk 1, Para. 3.2.11	Demonstrate that the GND can generate commands and that the ET can respond and provide appropriate data for the GND to perform fault isolation prior to vehicle mate.	GND analysis of ET data is sufficient to isolate detected faults to a functional path or to one or more LRUs.

TABLE 5.6 (DELETED)

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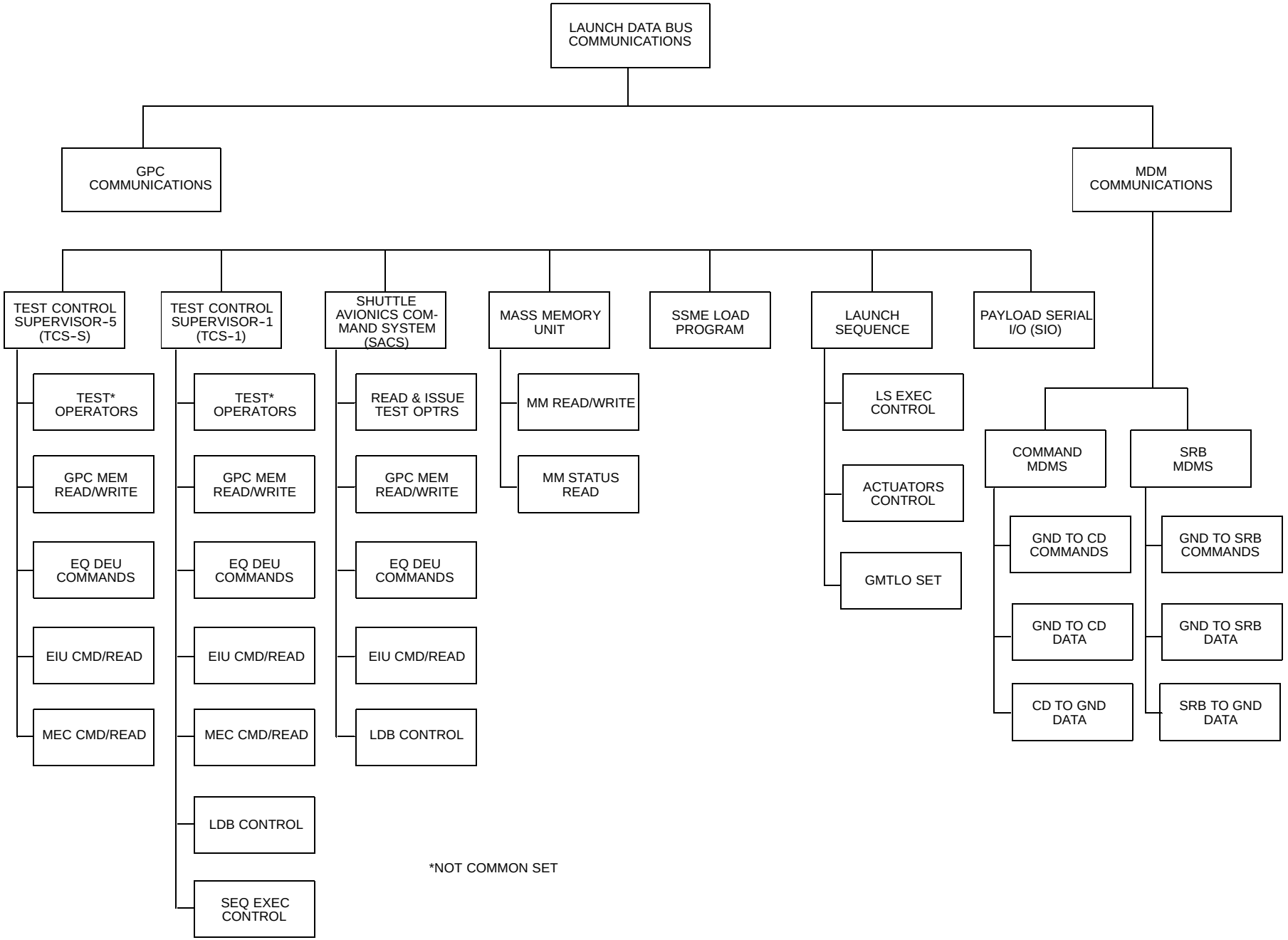
FIGURE 5-1

TYPES AND RANKS OF LDB COMMUNICATIONS



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6.0 FLIGHT OPERATIONS

This section deals with flight–to–ground system interfaces applicable to the flight operations portion of the mission. It is also laid out in a facility oriented organization.

6.1 MISSION CONTROL CENTER (MCC)

6.1.1 MCC/Orbiter Via STDN

Verification requirements for the MCC/Orbiter via STDN RF interface will ensure that the Orbiter and MCC have the following capabilities:

a. Orbiter transmits and MCC receives up to 128 Kbps of OFI data or an alternate low data rate of 64 Kbps.

b. Orbiter transmits and STDN receives up to 128 Kbps of DFI data and 15 analog data channels and up to 12 Kbps of ET (DFI) data (Orbital flight tests only).

c. MCC transmits and Orbiter receives 2.0 Kbps uplink command information.

d. Orbiter transmits and MCC receives wideband analog or digital data.

Specific interface test or analysis requirements, specifications and acceptance criteria are listed in Table 6.1. (Reference Appendix B for all MADS Configured Vehicles.)

6.1.2 MCC/Orbiter Via TDRS

Verification requirements for the MCC/Orbiter via TDRS interface will ensure that the Orbiter and MCC have the following capabilities:

a. Orbiter transmits and MCC receives up to 128 Kbps of OFI data or an alternate low data rate of 64 Kbps.

b. Orbiter receives and MCC transmits 2.0 Kbps of uplink command information.

c. MCC transmits and Orbiter receives up to 216 Kbps of wideband data.

d. Orbiter transmits and MCC receives up to 20 MBPS of wideband data.

Specific test or analysis requirements specifications, and acceptance criteria are listed in Table 6.2.

6.1.3 MCC/LPS/Network Interface

Verification requirements for the MCC/network interface will ensure the functional integrity between the LPS and the MCC ground computational systems.

The ability of the ground computational systems to process telemetry data and to transfer commands and data from one computer to the other shall be verified. The requirements and specifications are TBD.

6.2 AIR FORCE SATELLITE CONTROL FACILITY (AFSCF)

6.2.1 AFSCF/Orbiter Via SGLS

Interfaces are defined in ICD 2–0D003. It is expected the verification requirements will be similar to those for the MCC/Orbiter via STDN interface discussed in Section 6.1.1. Table 6.1 will detail these requirements.

6.2.2 AFSCF/Orbiter Via TDRS

Interfaces are defined in ICD 2–0D003. It is expected the verification requirements will be similar to those for the MCC/Orbiter via TDRS interface discussed in Section 6.1.2. Table 6.2 will detail these requirements.

6.3 PAYLOAD OPERATIONS CONTROL CENTER (POCC)

6.3.1 POCC/Attached Payloads

No data is available for this interface. It is expected that the ground/payload interface may be different for each POCC; however, the interfaces to be verified will probably contain some combination of requirements, similar to those of Table 6.1 and 6.2 in conjunction with Table 4.5 for the following RF links:

a. STDN

b. TDRSS

6.3.2 POCC/Detached Payload (Via Orbiter Relay)

No data is available for this interface. It is expected that the ground/payload interface may be different for each POCC; however, the interfaces to be verified will probably contain some combination of requirements similar to those of either Tables 6.1 or 6.2 in conjunction with Table 6.3 for the following RF links:

a. STDN

b. TDRSS

6.3.3 Orbiter/Detached Payload

Verification requirements for the Orbiter/detached payload interface are contained in Table 6.3. Those requirements pertain to (1) transfer of commands generated by the Orbiter Computational System and (2) monitoring and processing of telemetry data by the Orbiter Computational System.

TABLE 6.1

ORBITER/MCC INTERFACE VERIFICATION VIA STDN

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A004)	ACCEPTANCE CRITERIA
1. Verify ability to communicate uplink commands and data from MCC to Orbiter (including Backup Flight System) via MCC 'S' Band RF link.	Vol. XVIII, Bk 1, Para. 3.4.3 and 3.5.3	Issue uplink digital commands and data via 2.4 Kbps command channel encoded into 6.4 Kbps data sequence at both high (72 Kbps) and low (32 Kbps) data rates.	Received commands and data are as transmitted.
2. Verify ability to communicate telemetry downlink data from Orbiter (including Backup Flight System) via STDN 'S' Band PM RF link.	Vol. XVIII, Bk 1, Para. 3.4.4 and 3.5.8	Transmit realtime digital data via 128 Kbps telemetry channel at high data rate (192 Kbps). Transmit realtime digital data via 64 Kbps telemetry channel at low data rate (96 Kbps).	Compare received data to expected data for proper response.
3. Verify ability to communicate telemetry downlink data from Orbiter to MCC via STDN 'S' Band FM RF link.	Vol. XVIII, Bk 1, Para. 3.4.4 and 3.5.8	Transmit one (at–a–time) (a) Realtime main engine digital data (three independent 60 Kbps channels. (b) Realtime attached payload data (4MH_Z analog or 5 MBPS digital).	Compare received data to expected data for proper response.

(Reference Appendix B for all MADS Configured Vehicles.)

TABLE 6.1

ORBITER/MCC INTERFACE VERIFICATION VIA STDN – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A004)	ACCEPTANCE CRITERIA
		(c) Playback of any one recorded 60 Kbps main engine data channel at any one of four play–back speeds. (d) Playback of recorded 128 Kbps digital data at any one of three playback speeds. (e) Playback of recorded 192 Kbps TDM data at any one of two play–back speeds.	
4. Verify ability to communicate DFI telemetry downlink data from Orbiter to MCC via STDN ‘S’ Band FM RF link.	Vol. XVIII, Bk 1, Para. 3.4.4 and 3.5.8	Transmit realtime PCM data via 128 Kbps telemetry channel, FM data via 14 analog channels and ET PCM data via 16 Kbps.	Compare received data to expected data for proper response.

(Reference Appendix B for all MADS Configured Vehicles.)

TABLE 6.2

ORBITER/MCC INTERFACE VERIFICATION VIA TDRS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0D004)	ACCEPTANCE CRITERIA
1. Verify ability to communicate uplink commands and data from MCC to Orbiter (including Backup Flight System) via TDRSS 'S' Band RF link.	Vol. XVIII, Bk 1, Para. 3.4.3	Issue uplink digital commands and data via 2.4 Kbps command channel encoded into 6.4 Kbps data sequence at both high (72 Kbps) and low (32 Kbps) data rates.	Received commands and data are as transmitted.
2. Verify ability to communicate telemetry downlink data from Orbiter (including Backup Flight System) MCC via TDRSS 'S' Band.	Vol. XVIII, Bk 1, Para. 3.4.4	Transmit realtime digital data via 128 Kbps telemetry channel at high data rate (192 Kbps). Transmit realtime digital data via 64 Kbps telemetry channel at low data rate (96 Kbps).	Compare received data to expected data for proper response.
3. Verify ability to communicate uplink commands and data from MCC to Orbiter (including Backup Flight System) via TDRSS KU Band RF link.	Vol. XVIII, Bk 1, Para. 3.4.3	TBD	TBD
4. Verify ability to communicate telemetry downlink data from Orbiter (including Backup Flight System) to MCC via TDRSS KU Band.	Vol. XVIII, Bk 1, Para. 3.4.4	TBD	TBD

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TABLE 6.3

ORBITER/DETACHED PAYLOAD VERIFICATION REQUIREMENTS

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION	ACCEPTANCE CRITERIA
1. Verify the capability to communicate commands and data from Orbiter to payload via ‘S’ Bank RF link.	Vol. XVIII, Bk 1, Para. 3.4.24; Vol. X, Bk 1, Para. 3.3.1.3.3.4.2	*	* Proper sync., frame and format identification and data rates.
2. Verify the capability to monitor and process telemetry data from payload to Orbiter via ‘S’ Band RF link.	Vol XVIII, Bk 1, Para. 3.3.13, 3.4.21, 3.4.22; Vol. X, Bk 1, Para. 3.3.1.3.3.4.3	*	* Proper sync., frame and format identification and data rates. Compare received data.

* Reference specific payload ICD

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APPENDIX A

ACRONYMS AND ABBREVIATIONS

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APPENDIX A

ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFSCF	Air Force Satellite Control Facility
Anc'tr	Annunciator
Ant	Antenna
Assy	Assembly
Bk	Book
Baro	Barometer
BSM	Booster Separation Motor
Bw	Bandwidth
CA	Carrier Aircraft
CD	Command Decoder
CDDT	Countdown Demonstration Test
CHW	Control Header Word
Cmd	Command
Comm	Communication
Cond	Conditioning
C/O	Checkout
CPDS	Computer Program Development Specification
C&W	Caution and Warning
DC	Direct Current
DEU	Display Electronics Unit
DFI	Development Flight Instrumentation
DOD	Department of Defense
EIU	Engine Interface Unit
Elec	Electrical
EMI	Electromagnetic Interference
Engr	Engineering
ET	External Tank
Ext	External
Fac	Facility
FC	Flight Control
FDM	Frequency Division Multiplexer

FM	Frequency Modulation
FRF	Flight Readiness Firing
Fwd	Forward
GCILC	Ground Command Interface Logic Controller
GMT	Greenwich Mean Time
GN & C	Guidance, Navigation and Control
GND	Ground
GPC	General Purpose Computer
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HPU	Hydraulic Power Unit
HZ	Hertz
ICD	Interface Control Document
Intrgtr	Interrogator
Intrlvr	Interleaver
IOP	Input Output Processor
IRIG	Inter–range Instrumentation Group
JSC	Johnson Space Center
Kbps	Kilo Bits Per Second
KSC	Kennedy Space Center
KYBD	Keyboard
LDB	Launch Data Bus
LP	Launch Pad
LPS	Launch Processing System
LRU	Line Replaceable Unit
LS	Launch Sequence (or Launch Sequence Software Package)
L & L	Launch and Landing
MBPS	Mega Bits Per Second
MCC	Mission Control Center
MCDS	Multifunction CRT Display System
MDM	Multiplexer/Demultiplexer
MEC	Master Event Controller

MET	Mission Elapsed Time
MGMT	Management
MHz	Megahertz
MLP	Mobil Launcher Platform
MM	Mass Memory
MPT	Main Propulsion Test
MSS	Mission Specialist Station
MTU	Master Timing Unit
MUX	Multiplexer
MVP	Master Verification Plan
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
OCF	Orbiter Computational Facilities
OFI	Operational Flight Instrumentation
OI	Operational Instrumentation
OIC	Orbiter Integrated Checkout
OIT	Orbiter Integrated Test
OMRSD	Operations and Maintenance Requirements and Specifications Document
ORB	Orbiter
Para	Paragraph
PCM	Pulse Code Modulation
PCMMU	Pulse Code Modulation Master Unit
PLD	Payload
PM	Performance Monitoring
POCC	Payload Operations Control Center
Proc	Processor
PSK	Phase Shift Key
PSS	Payload Specialist Station
Pyro	Pyrotechnics
Pwr	Power
RCS	Reaction Control System
RF	Radio Frequency
RHW	Router Header Word
RPC	Remote Power Controller
SACS	Software Avionics Command Support
Sci	Scientific
SDC	Shuttle Data Center
Sec	Section

Sep	Separation
SGLS	Space Ground Link System
Sig	Signal
Sq	Square
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SS	Space Shuttle
SSME	Space Shuttle Main Engine
SSMEC	Space Shuttle Main Engine Controller
SSV	Space Shuttle Vehicle
Sta	Station
STDN	Space Tracking and Data Network
Sw	Switch
Sync	Synchronization
Sys	System
TBD	To Be Determined
TCS	Test Control Supervisor
TDRS	Tracking and Data Relay Satellite
TV	Television
TVC	Thrust Vector Control
USAF	United States Air Force
V	Volts
VAB	Vehicle Assembly Building
VAC	Vehicle Automated Checkout
VAFB	Vandenburg Air Force Base
Veh	Vehicle
Vol	Volume
Xmtr	Transmitter

APPENDIX B

VERIFICATION REQUIREMENTS FOR MADS CONFIGURED VEHICLES

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APPENDIX B

VERIFICATION REQUIREMENTS FOR MADS CONFIGURED VEHICLES

It is the purpose of this appendix to provide acceptance criteria for testing software for Space Shuttle Vehicles configured with a Modular Auxiliary Data Systems (MADS) in place of DFI and to provide specific requirements for integration verification of the computer systems and software for vehicles so configured.

The verification requirements for MADS configured vehicles are the same as those for DFI configured vehicles except as described in the following paragraphs. The paragraphs and tables are numbered hereunder to correlate directly with like parts of the basic document.

5.1.2 Other Orbiter Umbilical Interfaces

The LDB is the primary interface between ground and vehicle computational facilities. There are, however, other hardline interfaces that carry MADS and Operational Flight Instrumentation (OFI) data, as well as a limited command capability for specific subsystems. This section specifies requirements for verification of functional integrity of those hardware interfaces which connect GNC computational facilities to the following subsystems:

a. Engine Interface Unit

b. Master PCM Unit – OFI

c. PCM Loop and Maintenance Recorders

d. Network Signal Processors

e. MADS PCM

f. MADS Recorder

g. MADS FDM

h. Payload Signal Processor

i. Payload Integrator

j. Payload Recorder

Verification requirements for these interfaces are listed in Table B5.3.

5.3.1.5 Orbiter Processing Facility

The Orbiter Processing Facility (OPF) contains the equipment and consumable drainage and supplies to receive, safe, inspect, refurbish, prepare and checkout the

Orbiter for a given mission. This is the facility where the Orbiter integrated test is performed to verify Orbiter flight readiness. Verification requirements for this test are as indicated in Paragraph 5.2.3. Verification requirements for each of the Orbiter–to–Ground interfaces exercised at this facility are as indicated in the following sections of this document:

Interface	Requirement
Launch Data Bus	Paragraph 5.1.1
Engine Interface Unit	Table 5.3, Item 1
Master PCM Unit – OFI	Table 5.3, Item 2
PCM Loop and Maintenance Recorders	Table 5.3, Item 3
Network Signal Processor	Table 5.3, Item 4
MADS PCM	Table B5.3, Item 5
MADS Recorder	Table B5.3, Item 6
MADS FDM	Table B5.3, Item 7
	Item 8 (Deleted)
Payload Signal Processor	Table 5.3, Item 9
Payload Interrogator	Table 5.3, Item 9

Interfaces between the Orbiter and ground facilities used to verify ORB/ET, ORB/SRB, ORB/SSME, and ORB/PLD interfaces shall be verified in accordance with requirements in the following sections:

Interface	Requirement
ORB/ET Interface	Paragraph 4.1
ORB/SRB Interface	Paragraph 4.2
ORB/SSME Interface	Paragraph 4.3
ORB/PLD Interface	Paragraph 4.4

5.3.1.9 Shuttle Vehicle Assembly and Checkout Station

This station consists of the High Bay transfer aisle and High Bays 1 and 3. This is the location where SRBs, ET, and Orbiter are mated following final maintenance and preparation for mate. Interface verification in preparation for mating shall be performed in accordance with verification requirements in Paragraph 5.1.3 for SRBs and Paragraph 5.1.4 for the ET.

Mating of Shuttle Vehicle elements is done on the Mobile Launcher Platform (MLP). Shuttle checkout on the MLP will be limited to that required to verify the interface compatibility between elements and between the Shuttle Vehicle and ground equipment. Verification of functional integrity of each of these interfaces shall be performed in accordance with the requirements in the corresponding section of this document as indicated below:

Interface	Requirement
Launch Data Bus	Paragraph 5.1.1
Engine Interface Unit	Table 5.3, Item 1
Master PCM Unit – OFI	Table 5.3, Item 2
PCM Loop and Maintenance Recorders	Table 5.3, Item 3
Network Signal Processors	Table 5.3, Item 4
MADS PCM	Table B5.3, Item 5
MADS Recorder	Table B5.3, Item 6
MADS FDM	Table B5.3, Item 7
	Item 8 (Deleted)
Payload Signal Processor	Table 5.3, Item 9
Payload Interrogator	Table 5.3, Item 9
SRB Tail Plug	Paragraph 5.1.3
ET FM Multiplexer	Paragraph 5.1.4

5.3.1.10 Launch Pad Station

This station requires the most complete set of interfaces between ground computational systems and the Space Shuttle Vehicle. Verification of functional integrity of each of these interfaces shall be performed in accordance with the requirements in the corresponding section of this document as indicated below:

Interface	Requirement
Launch Data Bus	Paragraph 5.1.1
Engine Interface Unit	Table 5.3, Item 1
Master PCM Unit – OFI	Table 5.3, Item 2
PCM Loop and Maintenance Recorders	Table 5.3, Item 3
Network Signal Processors	Table 5.3, Item 4

MADS PCM	Table B5.3, Item 5
MADS Recorder	Table B5.3, Item 6
MADS FDM	Table B5.3, Item 7
	Item 8 (Deleted)
Payload Signal Processor	Table 5.3, Item 9
Payload Recorder	(TBD)
SRB Tail Plug	Paragraph 5.1.3
ET FM Multiplexer	Paragraph 5.1.4

Shuttle integrated tests shall be performed at the launch pad station in accordance with the verification requirements for prelaunch testing as indicated in Paragraph 5.2.6.

5.3.2 Palmdale Factory Checkout Facility

The primary computational interface between ground VAC equipment and the Orbiter is the launch data bus. Ability to conduct VAC/ORB communications on the LDB shall be verified in accordance with requirements stated in Paragraph 5.1.1.

The OFI data from the Orbiter are routed to VAC via a hardwire link at the T–0 umbilical. This interface shall be verified in accordance with Item 2 of Paragraph 5.1.2 and Table 5.3.

Acceptance criteria, specifications of interface performance, and configuration peculiar to Palmdale are contained in ICD 3–0607–01.

6.1.1 MCC/Orbiter Via STDN

Verification requirements for the MCC/Orbiter via STDN RF interface will ensure that the Orbiter and MCC have the following capabilities:

a. Orbiter transmits and MCC receives up to 128 Kbps of OFI data or an alternate low data rate of 64 Kbps.

b. MCC transmits and Orbiter receives 2.0 Kbps uplink command information.

c. Orbiter transmits and MCC receives wideband analog or digital data.

Specific interface test or analysis requirements, specifications and acceptance criteria are listed in Table B6.1.

TABLE B1.1

INTEGRATED COMPUTER SYSTEM VERIFICATION MATRIX

	REQUIREMENT	VAFB	KSC	SAIL	SSC	PMDL
Table B5.3: Umbilicals						
1	SSME Data			V		
2	PCMMU Data			V		E
3	Recorder Data + Control		V			E
4	Network Signal Processor Data (2 Way)			V		
5	MADS Recorder		V			E
6	MADS PCM		V			E
7	MADS FDM					
8	(Deleted)					
9	Payload Data		V (TBD)			
10	Payload Data Via FM					
11	Payload Recorder Control					
Table B6.1: Orbiter/MCC VIA STDN						
1	Uplink Commands		V	P*		
2	Telemetry Downlink–PM RF		V	P*		
3	Telemetry Downlink–FM RF		V	P*		
4	(Deleted)					

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FIGURE B4–1

ORBITER/ET FUNCTIONAL INTERFACE

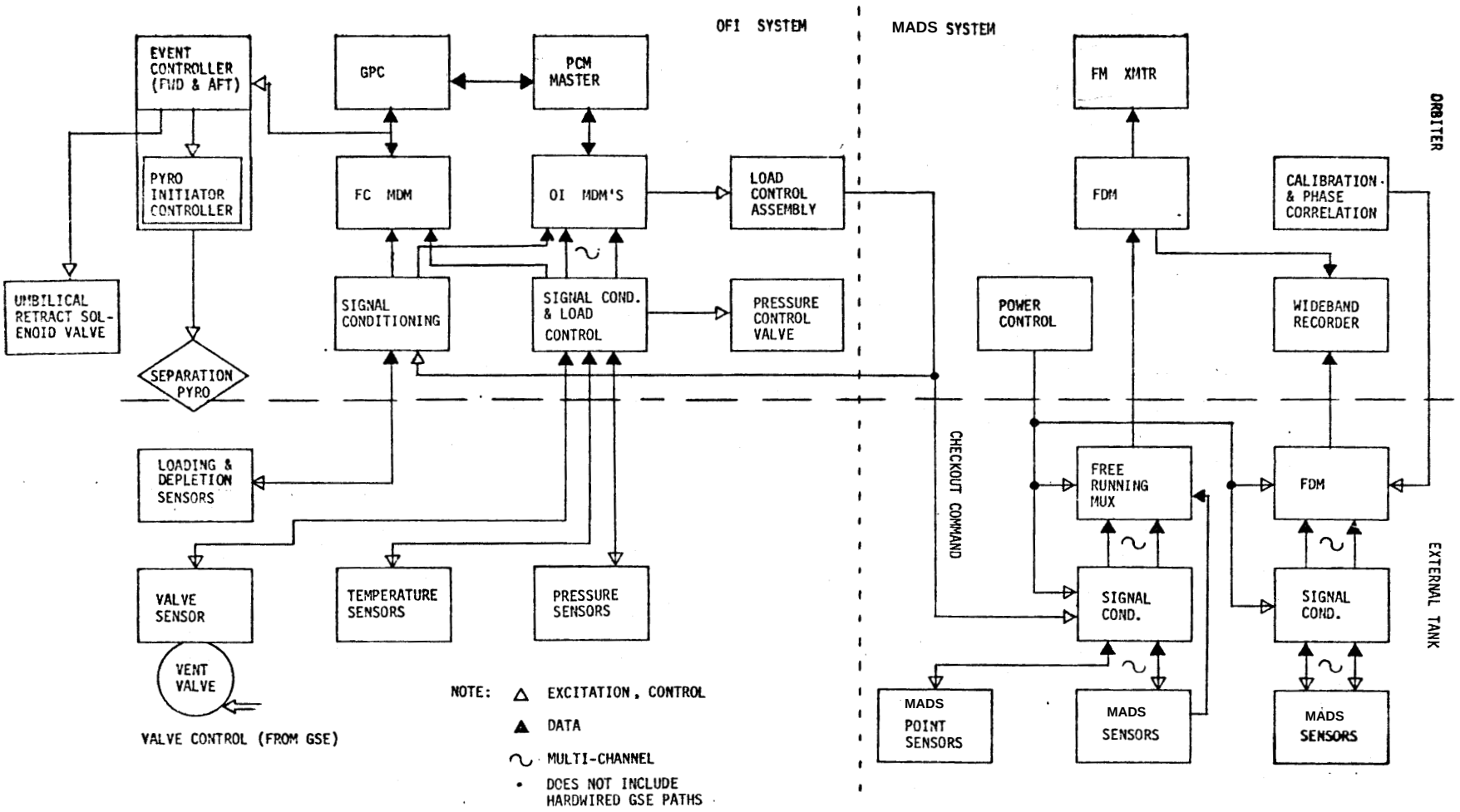

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TABLE B5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
1. Verify ability to monitor EIU and SSME performance	Vol. XVIII, Bk 1, Para. 3.1.2 and 3.3.2	Issue commands to EIU and SSME system via LDB and read 60 Kbps EIU/ GND hardlines for proper response, status, and parity per Section 5.0.	Data format, status content, and accuracy of transmission.
2. Verify ability to monitor SSV subsystems via PCMMU hardline interfaces, both the 128 and 64 Kbps links.	Vol XVIII, Bk 1, Para. 3.1.3, 3.2.2, 3.3.3 and 3.3.10	Issue commands to PCMMU–1 to exercise the various formats available and monitor the hardline PCMMU links for proper response format and content per Section 4.0. Repeat for PCMMU–2.	Proper synch, frame and format identification, and downlist and downlink organization in accordance with specific reports of the DIP (JSC 18206).
3. Verify ability to monitor and control the PCM loop and maintenance recorders using hardline GND links.	Vol XVIII, Bk 1, Para. 3.1.3, 3.2.2, 3.3.3 and 3.3.10	Issue commands to recorder–1 to record and then to dump data via hardline data dump links to ground and monitor these lines for proper response, format and content per Section 6.0. Repeat for recorder–2.	Data format, content, accuracy of transmission as well as rate of recording and dump applicable to each recorder as indicated in Section 6.0.

TABLE B5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES – Continued

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
4. Verify ability (including Backup Flight System) to communicate uplink and downlink with each of the 2 redundant Network Signal Processors via hardline GND links.	Vol. XVIII, Bk 1, Para. 3.3.4, 3.3.18 and 3.4.4	Issue uplink commands to OCF via NSP–1 and verify effect of command using PCM data from NSP–1. Repeat for NSP–2. Verify coded and uncoded commands and both high and low data rate modes per Section 7.0.	Proper synch, frame and format identification, data rates, and data content per Section 7.0.
5. Verify ability to monitor MADS for SSV subsystems via MADS PCM hardline interfaces.	MVP Vol. I, Para. 3.4	Issue commands to MADS PCM PMMI and monitor the hardline MADS PCM for proper response, format, and content per Section 8.0. Repeat for PMH2 when installed.	Proper synch, frame and format identification, and downlink organization in accord with specific reports of the DIP (JSC–18206).
6. Verify ability to monitor and control the MADS recorder using hardline GND links.	MVP Vol. I, Para. 3.4	Issue record and dump commands to the MADS recorder via LDB and monitor the hardline data dump link to ground for proper response, format, and contents, per Section 9.0.	Data format, content and accuracy of transmission per Section 8.0. Channel frequency deviation, pre–emphasis and format in accordance with Section 10.

TABLE B5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES – Continued

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
7. Verify ability to monitor MADS for SSV subsystems via MADS wideband FDM hardline interfaces.	MVP Vol. I, Para. 3.4	Issue command via the LPS to configure MADS for data hardwire from the FDM and monitor the four multiplexer outputs for performance in accordance with Section 10.0. For MADS systems containing an additional FDM, monitor the additional four multiplexer outputs for performance in accordance with Section 10.0.	Channel frequency, deviation, pre–emphasis, and format in accordance with Table 10.2.1–1.
8. (Deleted)			
9. Verify ability to monitor payload command data via the Payload Signal Processor and payload data via the Payload Data Interleaver and PCMMU hardline interfaces.	Vol. XVIII, Bk 1, Para. 3.1.14, 3.2.7, and 3.3.13	Issue command data from the GPCs and monitor via PSP–1 for proper response, format and content per Section 13.0. Issue simulated TM data via PSP–1 and monitor the hardline PCMMU links for proper response, format and content per Section 13.0. Repeat for PSP–2.	Proper synch, frame and format identification and data rates.
10. Verify ability to monitor payload data via the FM Signal Processor hardline interfaces.	Vol. XVIII, Bk 1, Para. 3.1.3	Select signal sources and monitor the response, format and content per Section 12.0.	Proper sync, frame and format identification and data content.

TABLE B5.3

VERIFICATION REQUIREMENTS FOR UMBILICAL INTERFACES – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
11. Verify ability to monitor and control the payload recorder using hardline ground links.	Vol. XVIII, Bk 1, Para. 3.1.3	Issue commands to the Payload Recorder and then dump via hardline data dump links to the ground. Monitor for proper response, format and content per Section 17.0.	Data format, content and accuracy of transmission as well as rate of recording and dump as indicated in Section 17.0.

TABLE B6.1

ORBITER/MCC INTERFACE VERIFICATION VIA STDN

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
1. Verify ability to communicate uplink commands and data from MCC to Orbiter (including Backup Flight System) via MCC 'S' Band RF link.	Vol. XVIII, Bk 1, Para. 3.4.3 and 3.5.3	Issue uplink digital commands and data via 2.4 Kbps command channel encoded into 6.4 Kbps data sequence at both high (72 Kbps) and low (32 Kbps) data rates.	Received commands and data are as transmitted.
2. Verify ability to communicate telemetry down–link data from Orbiter (including Backup Flight System) via STDN 'S' Band PM RF link.	Vol. XVIII, Bk 1, Para. 3.4.4 and 3.5.8	Transmit realtime digital data via 128 Kbps telemetry channel at high data rate (192 Kbps). Transmit realtime digital data via 64 Kbps telemetry channel at low data rate (96 Kbps).	Compare received data to expected data for proper response.
3. Verify ability to communicate telemetry down–link data from Orbiter to MCC via STDN 'S' Band FM RF link.	Vol. XVIII, Bk 1, Para. 3.4.4 and 3.5.8	Transmit one (at–a–time) (a) Realtime main engine digital data (three independent 60 Kbps channels). (b) Realtime attached payload data (4MH^<z^> analog or 5 Mbps digital).	Compare received data to expected data for proper response.

TABLE B6.1

ORBITER/MCC INTERFACE VERIFICATION VIA STDN – Concluded

REQUIREMENT	SOURCE NSTS 07700	SPECIFICATION (ICD 2–0A003)	ACCEPTANCE CRITERIA (ICD 2–0A003)
		(c) Playback of any one recorded 60 Kbps main engine data channel at any one of four play–back speeds. (d) Playback of recorded 128 Kbps digital data at any one of three playback speeds. (e) Playback of recorded 192 Kbps TDM data at any one of two play–back speeds.	
4. (Deleted)			